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DEPARTMENT OF AGRICULTURAL DEVELOPMENT
DEPARTEMENT VAN LANDBOU-ONTWIKKELING

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AGRICULTURAL RESEARCH
LANDBOUONAVORSING
1991



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Fruit and Fruit Technology	VV	Vrugte en Vrugtetegnologie
Viticulture and Oenology	WW	Wingerdbou en Wynkunde

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Highveld	H	Hoëveld
Karoo	K	Karoo
Natal	N	Natal
Transvaal	T	Transvaal
Free State	V	Vrystaat
Winter Rainfall	W	Winterreën

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Note: The Department issues a separate list of research workers and lecturing staff, which is obtainable on request from the Directorate of Agricultural Information, Private Bag X144, Pretoria 0001. Information in this edition covers the era 1989.04.01 – 1990.03.31.

Let wel: Die Departement reik 'n aparte lys uit van navorsers en doserende personeel, wat op aanvraag verkrygbaar is van die Direkoraat Landbou-inligting, Privaatsak X144, Pretoria 0001. Inligting in hierdie uitgawe dek die tydperk 1989.04.01 – 1990.03.31.

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FINALE VERSLAE OOR NAVORSINGSPROJEKTE

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REPORTS (SUMMARISED)

PLANT PRODUCTION PROMOTION

AGRONOMY RESEARCH

Summer grain

MAIZE

- *Nutrition*

GG.2111/05/3/4:

NITROGEN TRANSLOCATION, NITROGEN SINK AND PLANT COMPONENTS WITH REGARD TO EFFECTIVE NITROGEN UTILISATION BY MAIZE. 1983-1990

F.G. Adriaanse

Ten inbred maize lines were grown in a quartz sand culture at three nitrate: ammonium ratios and two nitrogen concentrations. Different plant characteristics were measured at flowering and after grain maturity.

At 100 mg Nl⁻¹ higher NH₄⁺ ratios did not decrease leaf area or dry mass of leaves and stems, significantly but for plant height this decrease was significant. At 400 mg Nl⁻¹ higher NH₄⁺ ratios did show a significant decrease in plant height, leave area, dry mass of leaves, stems and total dry mass. High ammonium ratios did not affect roots to the same extent as the above ground plant parts.

It was indicated that higher ammonium ratios tended to increase the accumulation of N in the stems after flowering but decreased the N translocation from the leaves. A 3:1 nitrate:ammonium ratio at 100 mg Nl⁻¹ which showed a higher N translocation loss from the leaves than any of the other N treatments was an exception to this rule.

- *Upgrading*

GG.2111/07/2/7:

THE INFLUENCE OF FORM OF NITROGEN ON RATE OF UPTAKE AND ASSIMILATION BY ZEA MAYS ON MAIZE. 1982-1986

F.G. Adriaanse

A bulky report consisting of ± 150 pages of above mentioned research was received. This report consists of a variety of published articles and research results of a very high technical standard. It is indicated that the Department of Agriculture and Water Supply was one of five funding sources for this research.

Effect of nitrogen ionex on photosynthesis on CO₂ compensation

The investigation into the effect of NO₃⁻ and NH₄⁺ on photosynthesis and photorespiration of leaves could be of considerable practical value. It has been proven that both N ions increase the CO₂ compensation point, NH₄⁺ in contrast to NO₃⁻, however, lowered the temp of net photosynthesis. This means a lower uptake of CO₂ in association with NH₄⁺ as compared to NO₃⁻ at high concentrations of CO₂. This finding is in accordance with other work done in this field. The importance of the effect of NH₄⁺ in the leaves is yet to be resolved, owing to the fact that most work was done on NH₄⁺ assimilation in roots.

It was found that NH₄⁺ enhanced the asparagin-amino acid level in the plant considerably. The different biochemical cycles of N metabolism were once again proven.

Nitrogen assimilation in different plant parts

The parts of the leaf with the highest nitrate assimilation was determined using N-15. It was proven that nitrate assimilation was the highest at the tip of the leaf. NO₃⁻ N concentration was the highest at the base of the leaf and it is believed that it is stored at this location. Nitrate reductase activity was also at the highest in the tip of the leaf. This finding explains to some extent why the highest rate of photosynthesis is also in the tip of the leaf.

The breeder which is interested in using nitrate reductase as a selection criterium, will be more successful by just analysing the tip of the leaf than the entire leaf.

The possible other futural implications of this research is that the accuracy of using certain parts of the leaf as standard for optimum nitrogen supply to the plant above using the entire leaf, which is currently a common practice, was proven.

Nitrogen supply to the maize embrio

It has been proven that uptake of nitrogen occurred only after the fifth day and that there is enough nitrogen in the endosperm to ensure continuous growth for the first seven days.

Thus N fertiliser should be available to the plant after seven days.

GG.2111/07/3/1:

BREEDING FOR GENERAL RESISTANCE TO MAIZE DISEASES. 1978-1990
K.R. Chambers

The report, as presented, has been published in *Plant Disease*.

Previous publications have suggested DIMBOA and pith density to be a factor in stalk rot resistance but this report places doubt on these as criteria for resistance.

The finding that root rot, stalk rot and lodging showed dominance suggests that breeding for resistance may be relatively simple.

The fact that disease was lowest in lines with the longest growing season requirements supports Dodd's (1978) theory of cell senescence and stalk rot severity. Attention needs to be given to the selection of slow stalk senescence genotypes.

Because of the resignation of the responsible officer and the unavailability of staff to continue this facet, its termination is recommended.

• Pathology

GG.2111/19/4/1:

EPIDEMIOLOGY OF ROOT, STALK AND EAR ROT OF MAIZE AND RESISTANCE OF THE CROP TO THE DISEASE. 1981-1990
K.R. Chambers

A dryland maize trial was planted at Potchefstroom for two consecutive seasons. The rate of pith senescence, the sugar and β -glucoside content, pith density and moisture and the fungal infection of the maize stalk was monitored throughout the growing season. Stalk samples were taken regularly from differentiation through to maturity. The most frequently isolated genus was *Fusarium*, of which *F. moniliforme*, a known pathogen of maize stalks, was the most frequently found species. *Acremonium* was the next most frequently isolated genus. Other known pathogens of maize, like *F. graminearum* and *Diplodia maydis*, occurred at low frequencies.

The rate of pith cell death was fairly slow and appeared to be similar in all internodes. The soluble sugar concentration in the stalks increased slowly to reach a peak at between 80-100 days after plant emergence. The results tend to indicate that the rotting process of maize stalks is an interaction between the host plant condition and certain, as yet unidentified, climatic conditions.

GG.2111/19/4/3:

A STUDY ON *PYTHIUM* SPP. INVOLVED IN ROOT ROT OF MAIZE. 1984-1990
S. Visser

Soil samples were selected at random in the most important maize producing areas of South Africa. These samples were examined for the presence of *Pythium* spp. Approximately fifty per cent contained *Pythium* spp., *P. irregulare* and *P. ultimum* var. *ultimum* were common, whereas *P. aphanidermatum* was sporadically isolated.

In vitro all *Pythium* spp. proved pathogenic towards maize seedlings of the cultivars SNK2338, PNR6429 and PNR6546. The isolates caused a necrosis of the roots and inhibited root growth. Cultivars reacted differently to infection by various isolates. Clear differences in susceptibility were noticed amongst cultivars.

GG.2111/20/2/1:

COMPARISON OF CHEMICAL CONTROL APPROACHES AGAINST THE MAIZE STALK BORER, *BUSSEOLA FUSCA* (FULLER) (LEPIDOPTERA: NOCTUIDAE) IN MAIZE IN SOUTH AFRICA. 1959-1988

G.D.J. van Rensburg

Field experiments were conducted at three ecologically different localities to evaluate the influence of insecticidal sprays applied at different plant growth stages on maize stalk borer (*Busseola fusca*). The differential influence of control measures based on preventative treatment and on the economic threshold principle was also compared.

Spraying after tasseling reduced ear damage, but did not increase yield. Control measures based on an economic threshold of 10 % plants showing visible damage, proved to be superior to a preventative spraying programme with regard to both larval control and the resulted yield. Preventative spraying programmes were found to be uneconomical and ineffective, since this practice does not take either the presence or the size of infestation into account.

Control measures should be taken before the tassel is furled in the last leaf. The use of an economic threshold based on either egg or larval infested plants is, therefore, advocated to ensure effective control of *B. fusca*.

GG.2111/20/5/1:

BIOLOGY AND ECOLOGY OF FALSE WIREWORMS IN MAIZE. 1979-1988

T.W. Drinkwater

Six species of *Somaticus* that attack maize (*Zea mays* L.) in South Africa, have been identified. Their geographical distribution has been studied and mapped. The environmental factors directly or indirectly correlated with the natural food plants of these appeared to be the most important factor that effect the distribution of *Somaticus* species. The subterranean parts of maize seedlings were damaged and the plant population density in individual fields was decreased by more than 60 %. Various other crops were also attacked. By comparing the subterranean damage symptoms of maize with those of other soil insects an identification key for soil insects with respect to damage symptoms has been drawn up.

Methods to breed *Somaticus* species in the laboratory have been developed. The biology of *S. angulatus* was studied in the field and in the laboratory. The number of instars varied from 7-11. They overwintered as larvae and had only one generation per year.

The larvae of six *Somaticus* species have been studied morphologically and an identification key has been compiled.

Various laboratory trials indicated that false wireworms are not controlled in maize by the systemic action of insecticides applied in the soil. In pot trials the pest was effectively controlled by the apparent repellent effect of furathiocarb 66,6 % seed treatment when the seed was shallowly planted.

GG.2111/20/6/1:

THE DISTRIBUTION AND INCIDENCE OF THE GRAIN SORGHUM STEM BORER, *CHILO PARTELLUS*, ON MAIZE. 1984-1988

J.M. Bate

The sorghum stem borer, *Chilo partellus* (Swinhoe) is known to occur on the Springbok and Makatini Flats in South Africa. A recent survey over two seasons revealed the occurrence of *C. partellus* in the maize producing area of the Highveld.

The pest was found to occur widely in the western part of the Highveld, even as far south as Wepener in the Orange Free State. A comparison of climographs indicated that the insect has adapted to new environmental conditions. It is probable that the pest could spread to the eastern part of the Highveld.

GG.2111/20/8/4:

OCCURRENCE, DISTRIBUTION AND ECOLOGY OF ENDOPARASITIC NEMATODES ON MAIZE IN THE MAIZE GROWING AREAS. 1985-1988

E.M. Jordaan

Eight endoparasitic nematode species were recovered from 170 maize root samples in the Western Transvaal, Republic of South Africa. *Pratylenchus zeae* had the highest average population density (17 454/5 g roots), followed by *Pratylenchus neglectus* (5 827/5 g roots), *Pratylenchus penetrans* (5 617/5 g roots), *Pratylenchus brachyurus* (3 060/5 g roots), *Meloidogyne incognita* plus *Meloidogyne javanica* (301 larvae/5 g roots), *Pratylenchus crenatus* (130/5 g roots) and *Rotylenchulus parvus* (64/5 g roots).

The 17 reasonably homogeneous farming areas surveyed could be ranked on the basis of the incidence of the prevalent nematode species. A positive relationship was found between the incidence of *P. brachyurus* and *R. parvus* and long-term average annual rainfall. The incidence of *P. penetrans* and the *Meloidogyne* spp. was positively related to a combination of percentage sand and long-term average annual rainfall.

• Water requirements

GG.2111.31 2, 3:

THE RELATIONSHIP BETWEEN THE ROOT DISTRIBUTION AND WATER EXTRACTION PATTERNS OF MAIZE ON A BLEEKSSANDSERIE UNDER DRYLAND CULTIVATION PRACTICES. 1987-1988

L. Wilken

The influence of different row widths on water consumption and root distribution patterns of maize under dryland conditions was studied. The experiments were laid out at two localities. Soil of both localities consisted of Avalon soil forms with one a Bleeksand and the other a Soetmelkserie, respectively. Water tables were present at both localities. Three replications, each consisting of three row widths namely 1, 1,50 and 2 m at a constant plant population of 26 000 plants per hectare were planted at both localities. Leaf areas of three plants per plot and rooting density were measured at weekly intervals with a neutron moisture gage. Apparently no water stress occurred during the growing season.

At both localities a decrease in leaf area index (LAI) occurred as row widths increased. Rooting densities (LV) of both localities showed significant differences between soil depths with a decrease in LV with depth. Narrow row widths, although non-significant, showed higher root length indexes than wider row widths. At both localities evapotranspiration rate (ET) reached a maximum during the flowering stage. A higher ET, as well as yield, occurred at the narrow row widths. This tendency also occurred with water use efficiency where narrow row widths performed the best.

GRAIN SORGHUM

• Physiology

GG.2112/03/1/1:

A PHYSIOLOGICAL INVESTIGATION OF GRAIN SORGHUM LINES UNDER MOISTURE STRESS CONDITIONS. 1985-1986

A.J. Pretorius

The aim of this study was to investigate a number of morphological and physiological properties of sorghum, which may be correlated with drought resistance, in order to determine a drought resistance index for twenty sorghum lines. This research forms a basis for the selection of lines which may be used in the breeding of drought resistant sorghum cultivars, which will yield high grain production even in dry areas.

The following eco-physiological aspects were investigated under wet, medium and dry soil conditions:

- Transpiration temp, diffusion resistance, leaf temperature and cuvette/leaf temperature difference measured with a diffusion porometer
- Leaf water quality, determined by the leaf disc method
- Leaf water retention ability, determined by the cutting of leaves
- Photosynthesis temp, determined by the $^{14}\text{CO}_2$ method
- Chlorophyll concentration, measured by a spectrophotometer
- Grain production was determined

Thirty morphological properties were also investigated under the mentioned soil conditions. The results of multi-variate analysis (classification and ordination) applied to these properties could not be correlated with drought resistance. Four morphogloclal properties, namely plant height, number of leaves per plant and the length and width of the middle leaf were investigated intensively.

Morphological and physiological properties positively correlated with drought resistance are:

- Diffusion resistance
- Leaf temperature
- Leaf water ability
- Leaf water quality at saturation
- An extensive root system

Properties negatively correlated with drought resistance are:

- Cuvette/leaf temperature difference
- Leaf water quality
- Transpiration temp
- Number of leaves per plant
- Chlorophyll concentration
- Photosynthesis temp
- Grain production

From transpiration temp, diffusion resistance, leaf temperature, cuvette/leaf temperature difference and leaf water retention ability, a relative drought resistance index was calculated. Sorghum lines with a high drought resistance percentage are the most drought resistant. Transpiration temp is considered the most suitable single criterion for the determination of drought resistance under dry soil conditions, as this property coincides greatly with the relative drought resistance index.

Only values obtained under dry soil conditions coincide with the drought resistance index which was compiled from the relative drought resistance percentage.

Information obtained from and techniques developed in this study may be useful applied in the selection of drought resistant lines, or to breed drought resistant sorghum plants with high production, even under dry conditions.

Small grain

WHEAT

• Pathology

GG.2121/19/1/3:

THE EFFECT OF CROP ROTATION AND FERTILISATION ON THE INCIDENCE OF TAKE-ALL IN IRRIGATED WHEAT NEAR BRITS. 1983-1988

E.M.C. Maas

Crater disease soil was cultivated by tining, ripping or ploughing. Ripping, and particularly ploughing, increased soil penetrability, reduced inflection of wheat roots by *Rhizoctonia solani*, and enhanced plant growth.

Incidence and viability of *R. solani* in the variously cultivated soils were inconsistent. The controlling effect of ripping and ploughing is attributed to better root development and to temporary disturbance of *R. solani* in the soil.

Protein and oil seeds

GROUNDNUTS

• Crop science

GG.2131/30/2/5:

BASIN TILLAGE IN GROUNDNUT PRODUCTION. 1985-1988

E.B. Birch

The objective of this investigation was to determine the potential of basin tillage to increase groundnut yields on soils having a relatively low infiltration rate. The yield increasing potential of basin tillage is based on improved moisture conservation achieved by retaining run-off in the basins until infiltration has taken place, thereby minimising run-off and making better use of the rainfall.

Basin tillage 6 weeks after planting on a Westleigh soil at Potchefstroom increased the seed yield by 12% in comparison with conventional flat soil surface tillage. This yield increase was similar to that achieved in an adjacent sunflower trial and would have been greater had the basins been made slightly earlier as most of the 57-mm rainstorm that occurred after emergence, was lost as run-off. Basin tillage after planting was difficult to do in 90-cm rows without ridging the groundnut rows but should be a commercial proposition in rows 100 cm or more apart.

Basin tillage from the spring on an adjacent site the following year promoted stronger vegetative growth. As a result of the very severe drought caused by the annual rainfall being 154 mm less than average and high evaporation rates, stronger growing basin-tilled groundnut plants suffered more severe moisture stress late in the season and produced 14% lower seed yield.

At Warm Baths basin tillage from the spring on a Shorrocks soil series apparently conserved more moisture and the crop made much stronger vegetative growth than the control and produced 30 % more hay. The severe drought in the second half of summer and low annual rainfall caused these plants to suffer severe moisture stress with the result that the seed yield was only increased by 6 %.

On the average the seed yield was only increased by 6 % under severe drought conditions. Greater yield increases would probably have been recorded under average rainfall conditions. As groundnuts are annually grown on the lighter soils when infiltration and run-off are less important in the main production areas. Basin tillage of groundnuts should only be considered on soils where appreciable run-off occurs in medium and lower rainfall areas.

SUNFLOWERS

• Pathology

GG.2132/19/2/1:

BACTERIAL STEMROT OF SUNFLOWER. 1985-1987
L. van der Walt

Bacterial stem rot was first discovered at Burgershall during 1985 and 1986. Typical symptoms of the disease are soft rot of the stem and dark brown discolouration of the infected tissue.

The organism that causes bacterial stem rot on sunflower was identified as *Erwinia carotovora* var. *carotovora*. Preconditions, such as damaged tissue, are required for infection. In this case the fungus *Alternaria helianthi* causes a lesion through which the infection can penetrate the sunflower stem and cause the disease. It was found that the disease only developed during warm, wet conditions.

• Crop science

GG.2132, 30/2/1:

BASIN TILLAGE IN SUNFLOWER PRODUCTION. 1984-1989
E.B. Birch

In the semi-arid summer cropping areas of South Africa inadequate moisture is usually the dominant primary factor limiting dryland crop fields. In these areas more drought tolerant crops like sunflower and grain sorghum are favoured on heavy black clay soils (vertisols) as these soils are more prone to drought than medium textured soils. The drought proneness may be attributable to part of the rainfall being lost as run-off, although the high evaporation losses on these self-mulching, deep cracking soils and the high water holding capacity, are also contributory.

Basin tillage (furrow-disking or tie-ridging) is one of the few practical methods for virtually eliminating run-off and associated soil erosion. The basins are usually formed by placing mounds of soil across furrows to form small basins. Rain that would otherwise have run off is retained in the basins and infiltrates into the soil over a period of time.

This investigation was done to assess the potential of basin tillage on heavy black clay Arcadia and shallow Westleigh soil forms. The main objective was to improve moisture conservation in the soil by stopping run-off and improving infiltration on these soils that are prone to run-off in an endeavour to increase sunflower yields in marginal cropping areas.

Basin tillage was compared with conventional flat soil tillage on Arcadia soil forms at the Towoomba Research Station near Warm Baths over 4 years, at the Grain Crops Research Institute (GCRI) at Potchefstroom over 2 years and during 1 year at Greylingstad, Marikana and Settlers. The trials on the Westleigh soil form were conducted over 3 years at the GCRI. New sites were usually used each year. The basins were formed by drawing flat bottomed furrows and ridges 1 m apart, 15 to 20 cm high with 30- to 40-cm bases using 66-cm lister bottoms. Cross walls were usually made at 2- to 3-m intervals. The basins were usually rebuilt by hand-hoeing whenever necessary to keep them effective until harvesting. A randomised block design with six or four replicates was used. The gross plot size was usually 14 m x 7 m and the harvested plot 10 m x 3 m.

The basins were usually built in October or November after conventional primary and secondary tillage. The sunflower was usually planted on the ridge where applicable from November to January. Weedkillers, hand-hoeing or mechanical cultivation were used to control weeds. Conventional research procedures involving hand-planting, thinning and harvesting were used.

These studies indicate that run-off on high clay Arcadia and Westleigh soil forms under conventionally tilled sunflower is appreciable and probably averages 15-30 % of the rainfall. Basin tillage was effective in retaining this run-off on the land until infiltration had occurred.

The outstanding increase in sunflower seed yield of 33,3 % achieved with basin tillage over 12 trials is attributed mainly to this tillage system, retaining most of the rainfall and being much more effective in

conserving moisture under conditions favouring run-off. The mean response was similar on both soil forms. It seems possible that basin tillage practices could be improved and this could possibly increase the response to basin tillage even further.

Basin tillage is probably the most practical and effective means of improving sunflower yields in the medium and lower rainfall areas by minimising run-off on soils with a low infiltration rate, slope, good water holding capacity in areas where the rainfall intensity is relatively high and where the quantity of rain is usually inadequate. The greatest response is usually obtained under conditions favouring high run-off and where the soil moisture with conventional flat tillage is only adequate for low sunflower yields. Under very favourable rainfall or under severe drought conditions accompanied by little run-off basin tillage may not be effective in increasing crop yields.

DRY BEANS

• Crop science

GG.2134/30/1/8:

THE EFFECT OF HERBICIDES ON THE GROWTH AND DEVELOPMENT OF DRY BEAN
PHASEOLUS VULGARIS L. CULTIVARS. 1983-1986

A.P.J. de Beer

The tolerance of *Phaseolus vulgaris* (dry beans) to alachlor and metolachlor was investigated under field and controlled conditions (greenhouse and growth cabinet). The effect of various herbicide levels, cultivars, temperature regimes and moisture levels on dry beans tolerance was evaluated. To obtain a better understanding of the effects of alachlor and metolachlor at cell level on dry beans, microscopic studies were conducted.

The effect of various levels of alachlor and metolachlor on plant stand and seed production in different cultivars of dry beans was evaluated in field experiments, conducted at different localities. At recommended rates, dry beans displayed less tolerance to alachlor than to metolachlor. The cultivars Nep2 and Kamberg were generally more tolerant to both herbicides than the cultivar Nuweveld.

The effect of alachlor and metolachlor on seed germination, plant height, number of nodes, pod formation and seed mass were measured in pots in the greenhouse. Seed germination was not affected by alachlor or metolachlor, but further development of the plants of the Nuweveld cultivar was slightly retarded.

Results of the growth cabinet studies indicated that young bean plants were less tolerant to the herbicides at a lower temperature regime (25/15°C) than at the higher regime (30/20°C). In general, Nuweveld was less tolerant than Nep 2 and Kamberg. The effect of three moisture regimes (light sandy soil at 4%, 8% and 11% moisture levels) in combination with the herbicides generally resulted in the most damage, with the least damage observed at the 8% moisture level. Low soil moisture levels possibly caused slower growth of the coleoptile resulting in longer contact with the herbicide. At high moisture levels probably relatively more herbicide was absorbed in a shorter period.

The electron microscope studies showed that the mitochondria, chloroplasts and nuclei of the leaf tissue were damaged to varying degrees by metolachlor and alachlor. A possible explanation is that formation of Ko enzyme A that occurs in these cell organs is inhibited by alachlor and metolachlor.

This study demonstrates the importance of environmental and genetic factors in the response of dry beans to alachlor and metolachlor. Nuweveld was less tolerant to alachlor and metolachlor than either Nep2 or Kamberg. These results may contribute to the safer use of herbicides in dry bean (*Phaseolus vulgaris*) cultivation.

GG.2134/30 1 10:

THE ADAPTABILITY OF DRY BEAN CULTIVARS TO FACTORS ASSOCIATED WITH
ACID SOIL INFERTILITY WITH SPECIAL REFERENCE TO PHOSPHORUS NUTRITION.
1986

A. Schumann

Dry bean (*Phaseolus vulgaris* L.) cultivation on Oxisols and Ultisols in Natal was expected to benefit substantially by the selection of cultivars capable of producing economic yields at moderate levels of acid soil infertility. This "low input technology" would aim at identifying genotypes which produce 80% of the maximum yield with minimal soil amelioration. Selected cultivars could either be utilised immediately or incorporated into plant breeding programmes.

Two methods of rapid screening for tolerance to soluble Al, as well as field screening on two Natal Ultisols (Normandien and Doveton series) for tolerance to the full range of factors responsible for acid soil infertility, were attempted on populations of 100 bean cultivars. A more detailed field trial was conducted on six bean cultivars exposed to three levels of lime and P on these soils. Cultivar performances were assessed

on an absolute as well as a relative basis, and classified into "tolerant", "intermediate" and "sensitive" subsets by a simple statistical method. Performance and response indices to soil amelioration were also calculated for bean cultivars in order to differentiate between "efficient responders", "efficient non-responders", "inefficient responders" and "inefficient non-responders". Regression methods were used to investigate relationships between plant performance, soil chemical properties and leaf nutrient composition.

There was no correlation between rapid screening for Al tolerance and field screening assessments. The predictive value of these rapid screening methods for bean performance on these soils was therefore negligible. Confounding of the acid response by various factors, especially differential disease infestation and inherent cultivar interactions with the environment were proposed as reasons for these discrepancies. Linkage of acid tolerance with seed size of cultivars was considered unlikely but there were indications that increasing soil acid saturation may accentuate the generally superior performance of the cream speckled group of dry beans tested. This seed colour group contrasted with the significantly lower yields of the red-speckled group under acid soil stress. There were no significant interactions of cultivars with amelioration treatments, indicating that cultivar responses to soil acidity were similar. This was reaffirmed by a lack of significant cultivar differences observed for plant nutrient uptake from these acid soils.

At present, improvement of Natal dry bean production through selection of superior yielding and disease resistant cultivars was considered more urgent than selection for acid tolerance *per se*. Dry beans responded to both lime and P amelioration, but there were indications that the primary chemical limitation of these soils was a deficiency of nutrients, particularly P and Ca, whereas Al toxicity was less restrictive. An application of 16 g P m⁻² was sub-optimal, but a 800 g Ca(OH)₂ m⁻² application was considered adequate for dry bean growth on these soils.

Other agronomy crops

COTTON

• Nutrition

TK.2141/05/2/1:

QUANTITATIVE DETERMINATION OF NH₄⁺ AND NO₃⁻ IN SOIL EXTRACTS WITH THE AUTO ANALYSER. 1987-1988

C.J. Steenkamp

For the determination of NH₄⁺ and NO₃⁻ in soil extracts with the auto analyser, different methods were tested.

The methods as described by Rowland (1983) for NH₄⁺ and Bessinger (1985) for NO₃⁻ were the most suitable for our conditions.

For better peak separation in the concentration range of 0-6 mmol l⁻¹ certain modifications had to be made. The concentration of certain chemicals, as well as flow rate was modified to achieve these results.

The modified methods were tested against the standard Kjeldahl method, where R² = 0,99 for both NH₄⁺ and NO₃⁻.

By adding a known amount of NH₄⁺ and NO₃⁻ to the soil extract a better reclamation of added NH₄⁺ and NO₃⁻ was found with the AA method than with the Kjeldahl method. A mean value of 90 % for the Kjeldahl as to 97 % for the Auto Analyser was determined.

The accuracy and reproducibility of these methods to determine the NH₄⁺ and NO₃⁻ content in the soil, can be recommended.

• Crop science

TK.2141/30/1/1:

APPLICATION OF GROWTH REGULATORS ON COTTON. 1982-1987

M.C. Dippenaar

Growth stimulants were tested to make better use of a short growing season for cotton. Excessive vegetative growth which occurred under favourable growing conditions was controlled by evaluating different concentrations and stage of applications of the growth retardants, viz cycocel (ccc) and mepiquat. These trials were conducted at Barberton, Groblersdal and Rustenburg.

The commercial growth stimulants (brown seaweed extract, green seaweed extract, algae extract, cysteine and gibberellic acid) did not contribute positively to the short growing season, or improve seed cotton yield.

On the other hand, cycocel, which is one of the older growth retardants, reduced vegetative growth significantly, as well as yield. Applications of low concentrations (10 to 86 g a.i./ha) at 12 day intervals

resulted in an additive effect which resulted in the same growth and yield reduction as one application of cycocel. A dosage of 1 000 ml mepiquat per ha at a plant age of 60 days reduced plant height significantly without affecting seed cotton yields. This dosage may stop growth and the initiation of a yield potential, if moisture stress also occurs.

Mepiquat is a management tool to control unnecessary vegetative development of cotton under favourable conditions. A low dosage of 125 ml mepiquat per ha applied with the onset of square formation controlled undesirable growth of internodes of both the main stem and fruiting branches. As a guideline 14 day internodes was established as the controlled growth during the growing season.

Where growth persisted at a high rate the follow up application was required after seven days. Where growth was slow the 21 days interval between applications, was sufficient. Where very luxurious growth was experienced, seed cotton yield improved by the mepiquat spraying programme.

Fibre properties were never affected by mepiquat. This growth retardant is compatible with insecticides.

TK.2141/30/1/3:

THE INFLUENCE OF PLANT DENSITY AND ROW SPACING ON COTTON CULTIVARS.
1984-1986

M.C. Dippenaar

The response of cotton cultivars, viz Acala 1517-70, Acala 1517-E2, Selati and Tetra were determined at plant populations of 50 000, 87 000 and 125 000 plants per ha in two row spacings, namely 60 cm and 100 cm at a optimum planting date of 14-22 October and a late planting at the end of November. These trials were executed at Groblersdal and Rustenburg.

Seed cotton yield was consistently better in the 60-cm row spacing than the conventional wider rows. The October planting yielded 11,5 % higher in the narrow rows, whereas the late November planting performed 18,7 % better in the 60-cm row spacing, but the yield was lower than the October planting date. Plant population had no significant effect on cotton yield.

Although, good seed cotton yield (2 880 kg/ha) were harvested from the late season planting, it was 12,3 % inferior to the October planting. Of more importance was that the first picking of the cotton was harvested very late in the season (middle May to middle June). The fibre properties of the second picking of these late maturing crop indicated immaturity and 10,2 % weaker break strength.

The cultivars Acala 1517-70, Nebo, Selati and Tetra were planted in both row spacings at 80 000 plants per ha as a demonstration trial at Rustenburg. The beneficial effect of the narrow row spacing was confirmed. A high level of irrigation management produced exceptionally high yields of 6554 to 7440 kg/ha.

The average growth rate of these cultivars were used as a growth index with the amount of day degrees during the seasons as explanation for variation experienced in yields. Together with cultivar characteristics and plant height after 1 100 day degrees, more than 79 % of variation in seed cotton yield could be explained.

• *Water requirements*

TK.2141/31/1/2:

EFFECT OF MOISTURE DEFICITS ON DIFFERENT COTTON CULTIVARS AND
BREEDING LINES. 1982-1985

M.C. Dippenaar

The cotton growing season at Groblersdal was divided in 20-day periods numbered from A to F. During this period different plots were subjected to a moisture stress. A high soil moisture regime was maintained before and after a period of stress. Dryland cotton as well as irrigated plots were included. Changes in soil and plant moisture status were monitored and the effect on growth and yield were measured.

During stress period C the soil was dried out to wilting point up to a depth of 90 cm. At the end of this stress period the leaf water potential dropped below -3 100 kPa. During the first 600 to 900 day degrees after planting, cotton at all treatments, included dryland, developed well. Later in the season the growth was slowed down on dryland and with the stress C treatment. Stress period C coincided with the peak flowering period and after a brief flush in blooms per day a dramatic drop in blooms occurred. In comparison with the well-irrigated plots, seed cotton yield on stress C was reduced by 30-42 %. No significant differences in yield were recorded between cultivars.

To explain the variation in yield data, some indices were proposed for different growth parameters. A base line was developed to calculate a plant water stress index (PWSI) to compare moisture status of plants even under different conditions of evaporative demand.

The ratio of soil moisture plus rainfall and irrigation to soil profile available water proved to be an efficient index to convert potential evapotranspiration into effective water consumption. The product of the effective water consumption during a fraction of the growing season, and the corresponding RFT (remainder of the physiological time) as cumulative total over the season, explained 79,24 % of variation in seed cotton yield.

TOBACCO

• Nutrition

TK.2142/05/1/1:

INDEX FOR NITROGEN AVAILABILITY ON AN ARCADIA SOIL SERIE WITH RESPECT TO FLUE-CURED TOBACCO. 1972-1988

C.J. Steenkamp

In a field trial flue-cured tobacco was grown in rotation with oats and soybeans on an Arcadia soil. Firstly the oats was grown and the land left fallow for the whole summer and winter before the tobacco crop. For the last two seasons the oats was grown immediately before planting tobacco. For the first two seasons the soybeans were reaped and all material removed from the land. The last two seasons, however, the soybeans were ploughed in as a green manure at the early pod stage.

The results indicated that:

1. A fallow period of one year after oats is too long on this type of soil. Although the mineral nitrogen status of the soil was lower initially, mineralisation from the organic pool restored the inorganic nitrogen in the soil to the original level.
2. By reaping soybeans and removing all the material no nitrogen was incorporated into the soil.
3. Although a considerable amount of nitrogen was incorporated into the soil when soybeans are ploughed in at the early pod stage, this higher nitrogen status of the soil was not reflected in plant growth. The nitrogen was incorporated in the organic pool and was not available to the tobacco crop.
4. Inorganic applications of nitrogen to the soil were equalised by the soil.
5. The relatively low percentage of tobacco production in the lemon and orange grades, makes the economics of tobacco production in this specific soil type questionable.
6. Taking into account that the climate in the RSA is marginal for tobacco production, it would be short sighted to grow tobacco on this marginal soil.
7. From the results it is evident that with analyses of 6-10 ppm and 15-18 ppm mineral nitrogen, applications of 60 kg N/ha and 30 kg N/ha, respectively, gave the best results in terms of yield and quality.

• Pathology

TK.2142/19/2/5:

EVALUATION OF *NICOTIANA* SPP. AND *NICOTIANA TABACUM* CULTIVARS FOR RESISTANCE AGAINST BUSHY TOP ON TOBACCO. 1987-1988

D.J. de Bruin

This virus complex caused significant losses in some tobacco production areas in South Africa during the 1980, 81 and 1981/82 growing seasons and may start again at any time. By obtaining resistance to one of the viruses within the complex it may be possible to find resistance to one of the viruses and as such to "bushy top".

Thirty-two *Nicotiana* spp. and 43 tobacco cultivars were seeded and three weeks after transplanting "bushy top" was subtransmitted to the test plants. All cultivars were susceptible and only four *Nicotiana* spp. showed resistance with regard to *N. acuminata*, *N. excelsior*, *N. suaveolus* and *N. clevelandii*.

In view of the threat of bushy top to the South African tobacco crop, further research should be conducted to determine the value of these four *Nicotiana* spp. as sources for bushy top resistance.

TK.2142/193/3/1:

DETERMINATION OF THE OCCURRENCE, RACE AND BIOVAR OF *PSEUDOMONAS SOLANACEARUM* ON TOBACCO. 1985-1988

M.C. Engelbrecht

Bacterial wilt disease (*Pseudomonas solanacearum*), although common on various other crops in South Africa, appeared only during the early 1980's on tobacco locally (Engelbrecht & Prinsloo, 1985). It has increased rapidly since then and is now wide-spread in the Transvaal Lowveld. In the district of Groblersdal the disease is serious on a number of farms whereas no further reports since 1986 were received from Beestekraal, Brits.

All South African tobacco isolates tested, belong to race I biovar III. All reference tobacco strains belong to race I and biovar I or IV. Local tobacco strains are highly virulent on crops such as tomatoes, potatoes, pepper, eggplant and diploid bananas; a fact which are an even bigger menace to the cultivation of such crops.

Forty-six South African and 13 reference strains were also subjected to a numerical, phenetic analysis. Apart from 5 biovar II potato strains, all South African strains (tobacco, tomato, eggplant, pepper, *Datura*) belonged to biovar III and formed a group on their own.

To conclude, it is still not clear what caused the sudden occurrence of bacterial wilt on South African tobacco. However, different strains probably evolved independently in different regions of the world (Buddenhagen, 1986).

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• Pests

TK.2142/20/2/6: THE SUSCEPTIBILITY OF CROPS GROWN IN ROTATION WITH TOBACCO FOR WEEDS AND SPECIES AND RACES OF *MELOIDOGYNE* COMMONLY FOUND IN TOBACCO FIELDS. 1987-1988
J.C. Meyer

Plant-parasitic nematodes can survive for a long period only if actively growing susceptible hosts are available. The susceptibility of the host will determine whether nematode populations will increase or decrease. Rotation crops as well as weeds commonly found in tobacco fields may serve as hosts. *M. javanica* and *M. incognita* are the most important *Meloidogyne* species in South Africa. Only host races 2 and 4 of *M. incognita* are found in South Africa.

The aim of this study was to determine the extent of susceptibility of crop cultivars used in rotation with tobacco, as well as weeds, commonly found in tobacco fields, to *M. javanica* and specifically races 2 and 4 of *M. incognita* which are present in tobacco soils. This information will assist tobacco farmers in selecting the most suitable rotation system.

The results obtained show that big differences exist between cultivars, concerning susceptibility to *Meloidogyne* species and races. Wheat was more susceptible to *Meloidogyne* spp. than barley or oats. The wheat cultivars SST44 and Zaragosa, recommended for summer rainfall areas are very susceptible to root-knot nematodes, particularly race 4 of *M. incognita*. This indicates that cultivar susceptibility must be kept in mind when selecting crops for a rotation system.

Some weeds such as wild bindweed (*Convolvulus ulosepalus*), silver leaf bitter apple (*Solanum elaeagnifolium*), nettle-leaved goosefoot (*Chenopodium murale*) and wild lettuce (*Lactuca serriola*) are susceptible to infestations by these nematode spp. and may be the cause of a higher population to the detriment of the following tobacco crop, and should be eradicated as far as possible.

• Crop science

TK.2142/30/1/1: SPACING AND TOPPING OF FLUE-CURED TOBACCO. 1966-1983
M.P. Lamprecht

During the research period several experiments were conducted to obtain information on the effects of various spacing and topping treatments designed to produce different leaf numbers/ha on the characteristics of flue-cured tobacco. In the first experiment leaf size decreased with an increase of leaf number from 200 000 to 500 000/ha. In spite of the reduction in leaf size, yield and income were maximised when 400 000 leaves were grown/ha, whereas acceptable levels of N, total alkaloids and sugars were obtained in the cured leaf. In the second experiment 100-cm rows were considerably more productive than 125-cm rows, whereas the combination of 100-cm rows and 400 000 leaves/ha also produced a tobacco of acceptable quality. Neither yield nor quality of flue-cured tobacco was significantly affected by plant spacing provided the leaf number/ha was maintained by manipulation of topping height. A 50-cm plant spacing with plants topped to 20 leaves appeared to be preferable.

Flue-cured tobacco plants (*Nicotiana tabacum* L. cv. TL38) were topped early (TV), late (TL) or not topped at all (TO). These topping treatments were combined with no sucker control (SO) and chemical sucker control (SB). This third experiment (randomised blocks with five replications) was conducted at Kroondal (Rustenburg) in 1974/75, 1975/76 and 1976/77 as well as at Groblersdal and Nelspruit during 1976/77. The TVSB plant gave the highest price/kg (income/ha) as well as sugar and total alkaloid concentrations in the cured leaf. The treatment effects on total alkaloid concentration were significantly affected by seasons and localities. Significantly higher percentages with TV than with TO were obtained in seasons and localities in which high levels of total alkaloid occurred in the cured leaf.

There was an indication that 50 x 25-cm spaced *low profile flue-cured* tobacco plants, topped to seven (T7) or eight (T8) leaves, produced a high yield and income of good quality tobacco. The fourth study was undertaken to find more convenient combinations of spacing and topping. Five spacings and four topping treatments were combined in an experiment at Rustenburg and Nelspruit over four seasons from 1973/74. Growth, yield and income were studied. The 75/25 x 25 cm row spacing (twin rows, 25 cm apart, separated by 75-cm interrow space) combined with topping to eight leaves per plant compared very favourably in yield stability, price and income with the recommended 50 x 25 T8 combination. Since this treatment also resulted in relatively small, early maturing (± 80 days) plants, and because of its more convenient spacing, it should be considered an obvious alternative to the 50 x 25 T8 combination.

Nitrogen and total alkaloid levels were higher and sugar levels lower at Nelspruit than at Rustenburg. At both localities protein N, the nitrogen: total alkaloids ratio and sugar: total alkaloids ratio and filling value increased with increased leaf number per ha, but total alkaloids showed the opposite trend. The 50 x 50 cm and 75/25 x 50 cm spacings, i.e. plants topped lightly, were low in total alkaloids and high in sugars. On the grounds of the inadequate alkaloid levels and the high nitrogen: total alkaloids ratio these spacings cannot be recommended for high quality tobacco. The quality of the 50 x 25 cm, 100 x 12,5 cm and 75/25 cm spacings (plants topped deeply), on the other hand, was acceptable, and there was little to choose between them. However, the 75/25 x 25-cm spaced plants topped to eight leaves per plant, seem to be the best choice, bearing in mind its adequate interrow space, and its satisfactory yield and value demonstrated in an earlier study.

Experiments 5, 6 and 7 were conducted at Rustenburg to determine whether flue-cured tobacco (*Nicotiana tabacum* L.) cultivars differed in their suitability for *low-profile* production. The cultivars Hicks, TL28 and TL33 were compared under conventional cultural practices from 1973/74 to 1977/78, were subjected to different low-profile practices from 1975/76 to 1977/78 and, together with 22 others, were also compared under both low-profile and conventional procedures in 1977/78. Cultivar Hicks, was lower in price and income than TL33 when grown by conventional methods, but was equal to TL33 and TL38 in both yield and income when subjected to low-profile procedures.

Hicks increased its yield, income and total alkaloid concentration and reduced its sugar concentration considerably more than TL33 and TL38 when grown as low-profile tobacco. The results showed that flue-cured tobacco cultivars, suitable for low-profile cultivation, must be chosen under low-profile conditions and that suitable cultivars, subjected to this procedure, could be highly productive and conducive to high quality.

This research facet has finally been exploited to indicate the relative suitability of certain flue-cured tobacco lines for low-profile procedures. Certain lines, such as NC13 x 38F6, were extremely suitable for low-profile production and has already been extensively utilised in the breeding programme. The very considerable advantages of low profile methods over the conventional in terms of both productivity and quality and the possibility of increasing these advantages by breeding extremely suitable cultivars, require the evaluation of newly bred superior lines for this specific purpose.

HORTICULTURE RESEARCH

Tuber crops

POTATOES

• Pathology

GS.2411/19/2/1:

BACTERIAL WILT DISEASE OF POTATOES CAUSED BY *PSEUDOMONAS SOLANACEARUM*: ISOLATION OF THE CAUSAL BACTERIUM. 1984-1988

A.E. Swanepoel

The purpose of this facet was the isolation, identification and maintenance of virulent strains of *Pseudomonas solanacearum* and to conduct a survey of the occurrence and distribution of the different biotypes of the pathogen in South Africa. Fifty isolates of the pathogen were obtained from diseased potato, tomato and tobacco plants and stored in sterile, distilled water. They were classified according to the biotype system, which is based on differences in biochemical characteristics.

With one exception the isolates from potatoes were all identified as biotype 2 and all but one of those from tomato and tobacco as biotype 3. Biotype 3 was mainly found in the hot, subtropical areas of the country and biotype 2 in the temperate regions.

Two other classification systems were also tried. Twenty-nine isolates could be classified in 7 groups on account of differences in sensitivity to 8 bacteriocin producing strains. At 30 °C the growth of biotype 2

isolates was inhibited by several biotype 3 strains. No biotype 2 strain, however, could inhibit the growth of any biotype 3 strain.

By using a method based on virulence to an egg fruit cultivar (Senyo-2-go) and 3 wild egg fruit species (*Solanum integrifolium*, *S. mammosum* and *S. torvum*) a distinction could be made between biotype 3 isolates from tobacco and tomato.

GS.2411/19/2/2:

BACTERIAL WILT DISEASE OF POTATOES CAUSED BY *PSEUDOMONAS SOLANACEARUM*: SYMPTOM DEVELOPMENT. 1984-1988

A.E. Swanepoel

The purpose of this research was to determine the effect of temperature on the development of bacterial wilt symptoms on potatoes and on the occurrence of latent tuber infection at different temperatures. Temperature had a great influence on the virulence of *P. solanacearum*.

It was found that biotype 2 isolates of the pathogen (usually isolated from diseased potatoes) were more virulent at temperatures of 22/25 °C (dark/light) and lower than the biotype 3 isolates (usually isolated from tomatoes). At temperatures of 14/16 °C (dark/light) an isolate of biotype 2 was able to cause wilting, visible symptoms on the tubers and latent tuber infection.

This isolate caused death of all treated plants at temperatures of 18/20 °C and higher. An isolate of biotype 3 caused wilting and tuber infection at temperatures from 18/20 °C upwards. Death of all plants inoculated with isolates of biotype 2 and 3 was observed at temperatures of 25-30 °C. The disease symptoms were, therefore, severe at higher temperatures.

At low temperatures, however, latent tuber infection did occasionally occur though the tubers were apparently healthy and the plants did not show symptoms of wilting. Latent tuber infection at low temperatures may be very harmful for potato production because seed potatoes are sometimes grown in cool weather.

Vegetables

TOMATOES

• Pathology

GS.2421/19/2/1:

EVALUATION OF TOMATOES FOR RESISTANCE TO BACTERIAL CANCER. 1975-1988

B.H. Boelema

The aim of the facet was to develop a method to test tomato cultivars and breeding lines for resistance to bacterial canker caused by *Corynebacterium michiganense* pv. *michiganense* (syn. *Clavibacter michiganense* subsp. *michiganense*). From a number of inoculation methods that were tested, the following method was chosen: the oldest true leaf of a tomato seedling was excised at the stem and immediately thereafter a drop of inoculum was applied to the wound.

The method has the following advantages:

1. It results in typical symptoms of bacterial canker
2. It does not require transplanting of seedlings
3. The dose, i.e. the number of cells of the pathogen applied per plant, can be regulated accurately.

The questions which arose were the following:

1. At what stage of development must the seedlings be inoculated?
2. What is the correct dose?

To answer these questions a great number of infectivity titrations were done in a glasshouse. It was found that plants become more resistant with age. Very young seedlings of a supposedly resistant line showed little resistance. Therefore, it was decided to inoculate plants after they had started to develop their 5th true leaf. The dose was found to be very critical. It should not exceed 6 cells of the pathogen per plant, because at higher doses competition for infection loci amongst cells of the pathogen occurred.

Application of low doses, however, created a problem, because cells of the pathogen died rapidly when they were suspended in low densities in sterile distilled water or Ringer's solution. The problem was

overcome by suspending the pathogen in nutrient broth (10 g dm^{-3}). Based upon the above findings a glasshouse test was developed. Tomatoes were sown in soil in 20-cm clay pots, one plant per pot, 26 plants per cultivar/breeding line. When they were approximately 5 weeks old, the oldest true leaf was excised at the stem and a $5\text{-}\mu\text{l}$ drop of inoculum was applied to the wound by means of a microsyringe. The average dose was 3 cells per plant. Four weeks after inoculation the plants were evaluated and the proportion of diseased plants corrected for multiple infection was taken as criterion. The amount of disease per plant was not taken into account (quantal response).

A disadvantage of the method is that each test requires much glasshouse space. Therefore, it was decided to develop a field test as well. The inoculation technique was essentially the same as that used in the glasshouse test, but the dose had to be increased considerably. Doses between 1 500 and 2 500 cells per plant gave satisfactory results. The time of inoculation was found to be very important. The plants continued to become more resistant with age. Differences in resistance between cultivars/breeding lines were, therefore, much more pronounced if the plants were inoculated 2-3 weeks after transplanting into the field than a fortnight later.

The application of the above methods was essential for the breeding of the cultivar Rotam 4, which has considerable resistance to bacterial canker.

GS.2421/19/2/2: PHENOTYPIC CHARACTERISTICS OF THE BACTERIAL SPECK PATHOGEN OF
TOMATOES (*PSEUDOMONAS SYRINGAE* PV. *TOMATO*). 1987-1988
J.J. Serfontein

Forty-five local and 10 reference strains of *Pseudomonas syringae* pv. *tomato* were tested for homogeneity within the pathovar. Numerical analysis on account of the results of 41 tests showed that South African strains belong to two closely related groups (relation coefficient 84,49 %).

Isolates could also be divided into two groups on account of their protein profiles, but the difference between the groups was very small. No relation was evident between the two grouping systems. Results of virulence tests in the greenhouse were all positive.

COLE CROPS

• Upgrading

GS.2423/07/1/2: COLE CROPS: BREEDING AND SELECTION OF CAULIFLOWER. 1976-1988
A.F. Coertze and A.A. van den Berg

The aim of the cauliflower (*Brassica oleracea* L. var. *botrytis* L.) breeding programme at Roodeplaat was to breed early open pollinated cultivars suitable for fresh market production in South Africa.

The breeding lines with the best plant and curd characteristics originated either from a cross between Snowcap and an early VOPRI breeding line or from the inbred progeny of the F_1 hybrid Snowcrown.

Two of these open pollinated breeding lines, 181-1 and 180/300-108, could as result of their performance in evaluation trials at Roodeplaat and in other areas, be considered for release as new cultivars for fresh market production under South African conditions.

• Water requirements

GS.2423/31/1/1: DETERMINATION OF THE WATER REQUIREMENTS OF COLE CROPS: CABBAGE.
1982-1988
P.F. Nortje

The effect of differential irrigation regimes on crop response regarding water use, yield and quality of cabbage (*Brassica oleracea*) was investigated over a period of five years.

Cabbage yields were significantly reduced by dry moisture regimes in both summer and winter. A study of plant organ development indicated a vegetative period during which leaf development constituted the main growth action, followed by a period of rapid head development. Severe soil moisture stress during the latter period decreased yields up to 60 %. Severe stress during the former period followed by frequent water applications during head development did not adversely affect yields or quality of heads.

Drier regimes enhanced maturity indexes and water stress early during plant development seemed to

favour internal compactness of heads implying earlier marketability. High plant populations tended to cause looser inner leaf arrangement indicating loss of quality. Frequent irrigations realised lowest solid percentages which pointed to higher quality regarding use as cole slaw. High incidence of tipburn or internal browning was observed at high frequency irrigations, as well as when water stress was induced during head development.

Higher total consumptive water use and deeper water extraction were recorded during summer in spite of the shorter growing season. Water use efficiency was increased by drier regimes and during cool growing conditions. Water savings were effected by drier regimes, but not by withholding water during the vegetative period, which caused extensive root development and consequently higher water extraction.

A crop factor of 0,5-0,6 for vegetative growth and 0,7 for the head development period was determined for winter production. During summer, results indicated factors of 0,7-0,75 for the former growth stage and 0,85 for the latter. Yield was positively correlated with the amount of water applied. Leaf water potential proved to be a suitable parameter for measuring internal water status of cabbage although sensitivity to changes in especially relative humidity was observed.

The calculation of growth functions for cabbage during both summer and winter for different irrigation regimes provides the basis for developing models for scheduling irrigation. This could lead to more effective and economical use of water in vegetable production.

ROOT CROP VEGETABLES

• Crop science

GS.2424/30/2/1:

ROOT CROP VEGETABLES: PHASE-II EVALUATION OF NEW CARROT CULTIVARS AND BREEDING LINES. 1981-1988

A.A. van den Berg and A.F. Coertze

The aim of this facet was to evaluate new and standard carrot cultivars and breeding lines in the different production areas. From 1981 until 1987 a number of trials were conducted at Roodeplaat, Glen and Addo which represents the Transvaal Middleveld, Central Free State and Eastern Cape, respectively. Twenty-three cultivars were evaluated in these trials. The results gained over the years enabled cultivar recommendations to be made for fresh market production in the various production areas on a number of different sowing dates.

The cultivar Kuroda is recommended for cultivation in the Transvaal Middleveld, Central Free State and Eastern Cape during the autumn. This cultivar produced high yields with excellent quality. The root shape tended to be cylindrical. At Roodeplaat Kuroda performed well at different sowing dates and can be cultivated successfully through the year.

The well-known standard cultivar Cape Market is recommended for cultivation in the Transvaal Middleveld and Central Free State during autumn. This cultivar produced exceptionally high yields of long heavy cylindrical roots. However, a small percentage of quality defects did occur. Cape Market cannot be produced from April until mid-August in the Transvaal Middleveld. The VOPRI line of Cape market performed better with regard to appearance and uniformity than the standard line.

The new F_1 hybrid carrot cultivars Lindora and Tarenco performed poorly regarding uniformity and yield. F_1 hybrid carrot cultivars evaluated in these trials are not recommended for cultivation.

The cold requirement of Banta, Duke and Regal is such that they can be successfully sown in mid-winter in the Transvaal Middleveld without any danger of bolting.

By harvesting the trials over eight weeks, it was found that a stabilising period occurred 110 days after sowing at the end of February in the Transvaal Middleveld. The length growth of the roots stopped and the external colour did not improve any further. The total soluble solids value also reached a maximum. On the other hand the leaf length, leaf mass and the percentage of forked roots remained constant during the harvesting period.

• Water requirements

GS.2424/31/1/1:

WATER REQUIREMENTS OF ROOT CROP VEGETABLES: CARROTS. 1982-1988

P.F. Nortje

The effect of differential irrigation regimes on crop response regarding water use, yield and quality of carrots (*Daucus carota* L.) was investigated over a period of five years.

Yield of carrots during winter was reduced by dry irrigation regimes and significant tendencies of increasing yield with increasing irrigation frequency were observed. Summer yields did not significantly differ between irrigation treatments. Alternating dry and wet moisture regimes during primary and radial growth stages did not result in yield effects. Leaf growth, however, was enhanced by frequent irrigations.

Growth studies indicated an initial primary growth stage followed by prominent radial growth which was associated with high water uptake during the latter period. Root deformities were mainly caused by adverse soil physical conditions induced by the dry moisture regimes and resultant long irrigation intervals during winter. Frequent water applications during winter decreased soil temperatures and thus resulted in lower beta-carotene levels causing less intense root colour. This phenomena was not observed during summer owing to smaller soil temperature differentials.

Solid content and shelf-life was detrimentally influenced by long irrigation intervals during winter plantings. Root length was inhibited and shoulder diameter increased by high frequency irrigations which emphasized the extent of influence of environmental factors on root appearance and quality.

Total consumptive water use of carrots during summer exceeded winter water use. The water needs for establishment of seedlings during summer accumulated to 200 mm resulting in lower water use efficiencies during summer. Slower root and leaf growth during winter resulted in less moisture being extracted from below 450-mm depths. Results indicated that irrigation depth should be deeper during summer as a result of high water uptake from deeper levels. A crop factor of 0,6 is recommended for winter months which should be raised to 0,7 in spring to accomodate peak water use. Crop factors during summer varied from 0,95-1,1 based on water extraction up to 600-mm depths.

The calculation of growth functions for carrots during both summer and winter for different irrigation regimes provides the basis for developing irrigation scheduling models. This could lead to more effective and economical use of water in vegetable production.

LEGUME VEGETABLES

• Crop science

GS.2425/30/1/1:

LEGUME VEGETABLES: PHASE-II EVALUATION OF GREEN BEAN CULTIVARS AND BREEDING LINES. 1975-1988

A.A. van den Berg

The aim of this facet was to evaluate the adaptation and performance of green bean cultivars and breeding lines in the most important production areas. The results obtained formed the basis for cultivar recommendations since 1975 and provided the data necessary for the release of breeding lines as cultivars. New cultivars with desirable characteristics for use as parents in the breeding programme were identified during the period 1975-1978.

The cultivar Thor was recommended from 1975 to 1979 for all production areas, with exception of the Lowveld. Thereafter, the cultivar became unobtainable and could no longer be recommended. Seminole and Wintergreen performed reasonably well. They are recommended for fresh market production in the Transvaal Middelveld, Free State and Lowveld, provided that the pods are picked at an early stage. Although Cape and Forte are not resistant to halo blight (*Pseudomonas syringae* pv. *phaseolicola*) they are recommended for processing on account of the excellent pod quality. Provider is recommended as a processing and fresh market cultivar for the Transvaal Middelveld, Eastern and Southern Cape.

The newly released VOPRI cultivars, Rolong, Roberg, Rominole and Rolatin, performed better than the above-mentioned cultivars and should replace them. Roberg and Rolatin are also recommended for processing.

Flowers and ornamental plants

PROTEAS

• Upgrading

GS.2431/07/1/4:

SINGLE PLANT SELECTION FOR THE DEVELOPMENT OF NEW CLONAL CULTIVARS OF PROTEAS. 1985-1989

G.J. Brits

This single plant selection programme formed Phase i of the VOPRI protea cultivar development

programme for the past 15 years. It entailed the selection of single plants from base material investigated in nature and in cultivated stands. The latter included plantations of private owners as well as the VOPRI's own segregating material.

The present collection contains 679 single plants of 6 South African and two Australian genera. From these a total of 21 cultivars had been developed and released to the Protea industry since 1979, for example by means of purposeful hybridisation of outstanding selections. As a group these cultivars probably excell other available cultivars with respect to both quality and diversity. The increasing quality of the single plant collection is reflected in the decreasing tempo of external acquisitions and the increasing selection from VOPRI segregating material.

In spite of great progress with individual selection and primary evaluation, serious shortcomings nevertheless exist in the present gene sources. These shortcomings are mainly determined by the inherent weaknesses of certain species and can only be removed by long-term breeding projects.

The present single plant collection is the largest and best collection of horticultural proteas in existence. It is, therefore, a valuable gene source for breeding improvement, as well as exchange and cooperative agreements with local and overseas instances. The work will be continued under the newly registered gene source facets for proteas.

CUT FLOWERS

• Physiology

GS.2433/03/1/5: RAPID MULTIPLICATION OF BULBOUS CUT FLOWERS IN VITRO : *NERINE*. 1986-1990
E. Louw

A tissue culture technique was developed for the rapid multiplication of *Nerine bowdeni*. Young daughter bulbs which were still inside the mother bulb were used as explants. The basal plate of these bulbs were cut off in such a manner as to remove the growing point at the same time. These basal plates were cut in half in a radial longitudinal plain and cultivated with their basal ends on the medium.

The medium consisted of Murashige & Skoog macro-elements at half strength; micro-elements at full strength, myo-inositol 100 mg dm⁻³, adenine 28 mg dm⁻³, L-tyrosine 100 mg dm⁻³, tiamine-HCL 30 mg dm⁻³, nicotine acid 10 mg dm⁻³, pyridocsine-HCL 1 mg dm⁻³, sucrose 30 g dm⁻³, IAA 0,5 mg dm⁻³, BAP 1 mg dm⁻³, agar 7 g dm⁻³. With this experiment a mean number of 5,5 bulbs were obtained from one explant.

GS.2433/03/1/6: RAPID MULTIPLICATION OF BULBOUS CUT-FLOWERS IN VITRO: *CYRTHANTHUS*.
1986-1990
E. Louw

An in vitro multiplication technique has been developed for *Cyrthanthus purpureus*. Young daughter bulbs which were still inside the scales of the mother bulb, were used as explants. The basal plate of this bulbs were cut off in such a way that the growing point was cut off at the same time. The plates were cultivated on the initial medium.

The medium consisted of Murashige and Skoog salts with the macro-elements at half strength and the micro-elements at full strength, myo-inositol 100 mg dm⁻³, adenine 28 mg dm⁻³, L-tyrosine 100 mg dm⁻³, tiamine-HCL 30 mg dm⁻³, nicotine acid 10 mg dm⁻³, pyridocsine-HCL 1 mg dm⁻³, sucrose 30 mg dm⁻³, BAP 1,5 mg dm⁻³, agar 7 g dm⁻³. The pH was adjusted at 5,7.

The usage of basal plates resulted in less contamination than when double scales were used as explants. The mean number of bulbs that developed on the basal plate were seven.

After these new bulbs had grown big enough, the same procedure could be used for subsequent multiplication. Rooting took place on a medium with 0,1 mg dm⁻³ NAA.

• Pathology

GS.2433/19/5/2: BULBOUS CUT FLOWERS: CHEMICAL CONTROL OF *UROMYCES TRANSVERSALIS* ON
GLADIOLUS. 1984-1993.
J.F. Ferreira

Bitertanol (Baycor) or triadimefon (Bayleton) provided the best control of *Uromyces transversalis* on gladiolus. These fungicides were compared with oxycarboxin (Plantvax), fenarimol (Rubigan), penconazole

(Filt), ethylenediaminetetraacetic acid (EDTA - Tetralon A), diethylenetriaminepentaacetic acid (DTPA - Tetralon B) and ethylenediaminetetraacetic acid containing 14 % copper (CuEDTA - Librel Cu).

Under conditions of high infection pressure weekly applications of bitertanol or triadimefon were necessary to ensure marketable flowers and a 1 to 1 return of gladiolus corms planted. Applications less often than weekly resulted in a drastic reduction in corm yield, abortion of flowers on the inflorescence and a linear increase in disease incidence. Weekly applications of bitertanol or triadimefon, however, caused a stunting of the inflorescence owing to the shortening of the internodes on the flower spike.

• *Crop science*

GS.2433/30/1/2:

SHRUB-LIKE CUT FLOWERS: HARVESTING CONTROL OF ROSES BY MEANS OF PRUNING PRACTICES. 1985-1990

A.M. van der Westhuizen

During the past season no treatments except the normal cultivation methods were used. Therefore, this season's data can be used as a control for the previous season. It is easy to see from the data that the yield increased in almost all the cultivars and that the peak flowering times were different. This was mainly due to climatic factors.

During the previous seasons it has been found that bud-breaking treatments caused a shifting in the flowering peaks of about a week but have a negative influence on yield.

Careful recording and constant care over labourers is essential to get a successful peak shift. Bud-breaking can be used by growers to shift the peak periods to receive better prices but it seems to be unpractical to implement this method successfully. The technique will only be scientifically justified when applied in a glasshouse where temperature and moisture can be controlled and when skilled and trained workers are used. It is recommended that this project be terminated because all the necessary information has been collected.

Pome and stone-fruits

PLUMS

• *Physiology*

VV.2444 03/4/2:

CHEMICAL COMPOSITION OF PLUMS WITH REGARD TO THE INCIDENCE OF INTERNAL BREAKDOWN. 1984-1988

K.H. Gürgen

During three seasons leaf samples were taken in October and at the end of January, and fruit samples were taken in October and at harvest time from 10 selected trees of the plum cultivars Santa Rosa, Harry Pickstone and Songold. Twenty orchards in the Stellenbosch, Franschhoek, Elgin and George areas were sampled.

The incidence of internal breakdown was evaluated after 4 weeks' storage at $-0,5^{\circ}\text{C}$ and one week at 22°C . Both leaf and fruit samples were chemically analysed according to standard procedures. Vigour of trees was evaluated according to amount of shoot extension growth.

Results were grouped according to cultivar, vigour and incidence of internal breakdown and were subjected to analyses of variance, principal component and multiple regression analyses. Optimum leaf and fruit composition for plums in October, leaves in January and fruit at harvest, of trees with normal vigour, were obtained from trees with low incidence of the disorder. The boundaries of the optimum range were calculated from the standard deviation.

Low incidence of internal breakdown was associated with significantly higher Ca, Mg and Mn content of leaves in October and with higher Na and low Zn content on 31 January. It is probable that vigour is the decisive factor causing inconsistencies in results reported in earlier publications.

Low incidence of internal breakdown was associated with significantly lower N content of fruit in October and with Ca and Mg content at harvest. The role of high Ca content of the fruit at harvest in restricting the incidence of internal breakdown, was again clearly illustrated.

Optimum leaf and fruit composition for plums in October and January or at harvest for trees with normal vigour was published. As regards leaf composition in January, there is a fair correspondence with

existing FFTRI standards, but for macro-elements the optimum ranges tend to be slightly higher.

There was no significant difference between optimum leaf composition for the different cultivars, except for the N content of Songold plums where a separate standard is recommended. The maximum N content of leaves for this cultivar is 2,8 %, compared to 3,15 % for Santa Rosa and Harry Pickstone. The maximum limit of the optimum range is considerably lower for Mn and Fe than that of the present FFTRI standard.

Previously no standards existed for composition of plum leaves in October or for fruit composition. These standards also probably have little value in practice. Considerable changes can take place in nutritional conditions and thus also in tissue composition during the long period between October and harvest. If deviations from standards in October are due to unfavourable climatic conditions, an improvement in nutritional conditions later in the season can result in a considerable improvement in fruit composition and quality at harvest.

In addition, few control measures can be taken during this period should any nutritional problems be identified. However, this standard could be used to ensure that fruit of poor quality is not exported, but then it should be borne in mind that other factors play a bigger role in the incidence of this disorder. Determination of fruit composition at harvest will be of little value owing to the relatively short storage life of plums.

A high incidence of internal breakdown was associated with low soil pH and Ca saturation and by high K and Mg saturation. A soil pH of approximately 6 should be maintained in order to restrict the incidence of physiological disorders.

The results obtained clearly indicate that mineral nutrient composition of plums play an important part in the quality of the fruit. However, other factors such as fruit maturity and temperature during storage may have greater effect on fruit quality after storage. Control of this disorder will, therefore, require an integrated approach which could optimise all factors involved.

Oenology

WINE

• Taxonomy

WW.2471/01/1/1:

THE RECOGNITION OF WINE YEASTS USING ENDOGENOUS PROTEIN PATTERNS AND FERMENTATION METABOLITES. 1985-1988

H.G. Tredoux

The wine industry relies on selected strains of a single yeast species (*Sacch. cerevisiae*) to ferment must to wine. Standard taxonomic techniques only identify micro-organisms to the species level and recurrent fermentation problems experienced by the wine industry made the development of a yeast strain characterisation technique an urgent necessity. Three techniques utilising the chemical components of the yeast cells or their secreted metabolites were considered. One hundred and four yeast strains, representing 39 yeast species, were examined after the strains were cultivated on a synthetic medium under rigidly standardised conditions.

Initial results generated by tube gel electrophoresis of endogenic proteins was encouraging. Reproducibility proved to be a problem possibly owing to non-reproducible cell breaking resulting in protein denaturation. Publication of a paper on reproducible species differentiation by tube gel electrophoresis (Van Vuuren & Van der Meer, *Am. J. Enol. Vitic.*, 38, 49-53, 1987) made further development work unnecessary.

Analysis of cellular fatty acids by gas chromatography proved to be an easier, more rapid technique. The cellular fatty acid profiles of 104 yeast strains, representing 39 species of wine associated yeasts, were examined by packed column gas chromatography utilising techniques developed in the Department of Microbiology, University of the Orange Free State. *Saccharomyces cerevisiae* had a unique fatty acid profile that clearly distinguished this species from all the other species included in this study. Strain differentiation was, however, not achieved because of the poor resolution of the packed column technique and other problems associated with the Bloemfontein technique. The potential power of a yeast strain characterisation technique based on the capillary gas chromatographic analysis of cellular fatty acids will be examined under a new facet.

Yeasts secrete metabolites into the medium in which they are growing. Gas chromatographic analysis of the volatile metabolites secreted by nine *Sacch. cerevisiae* strains produced profiles that clearly distinguished between these strains. If capillary gas chromatography of cellular fatty acids fails to affect differentiation

between yeast strains, this technique will be developed in an effort to achieve such differentiation between a large number of strains.

● Microbiology

WW.2471/08/1/4:

DETERMINATION OF THE PHYSIOLOGICAL AND TAXONOMIC CHARACTERISTICS OF MALOLACTIC BACTERIA IN WINE. 1986-1988

R.P. Tracey

In a numerical study, 70 MLB organisms of the genera *Leuconostoc*, *Pediococcus* and *Lactobacillus*, including 54 *Leuconostoc oenos* strains, five *pediococci* and 11 reference and type strains, were phenotypically characterized. The similarities between the different strains, based on 108 unit characters, were calculated using the Ssm coefficient and single linkage cluster techniques. Fifty eight strains grouped in six clusters at the 87% S level, but no reference strains were found to group in any cluster. The majority of the *L. oenos* strains grouped together at above the 91% S level. Based on specific differentiating characteristics, cluster A strains were regarded as "*Leuconostoc gracile*" as these strains are in general agreement with the description for this species as given by Bidan (1956).

The cellular fatty acid composition of the bacteria was examined by capillary gas chromatography. Of the 18 fatty acids determined, 10 were identified by gas chromatography-mass spectrometry. The major fatty acids were found to be palmitic, palmitoleic, oleic, vaccenic, dihydrosterculic and lactobacillic acid. It was mainly on the basis of the amounts of oleic acid and the C19-cyclopropane fatty acids that the *L. oenos* strains could be distinguished from each other. This is the first report of the occurrence of dihydrosterculic acid in lactic acid bacteria.

The volatile metabolites formed by 18 lactic acid bacteria, were extracted using a Freon 11 extraction method and analysed by capillary GC and by GC-MS. Of the 35 major peaks, 20 were identified and used to differentiate between the various strains. It was possible to differentiate between the strains of the genera *Lactobacillus*, *Pediococcus* and *Leuconostoc* and between the various species within the genus *Leuconostoc*. Nine of the 10 *L. oenos* strains included in this study yielded similar results. This technique was shown to be highly reproduced and various compounds not previously known to be formed by lactic acid bacteria, were identified.

The effect of certain amino acids (arginine, cystine, glutamic acid, iso-leucine, tyrosine, valine) on the growth and MLF of eight *L. oenos* and one *P. damnosus* strain was determined. The organisms differed greatly in their growth and MLF in the various media. It was found that *L. oenos* strains PSU1 and B66 and the *P. damnosus* strain were most affected in the different media, whereas *L. oenos* strains DSM 20252, 37D and 36 were the least affected.

The requirements for 18 amino acids and 13 growth factors were also determined. It was found that the *L. oenos* strains differed greatly in their requirements and no amino acid or growth factor could be regarded as essential to the growth of all strains.

A factorial design was used to determine the main effects and interactions of pH (3.6, 3.8 and 4.0), SO₂ (25 and 50 mg/l), ethanol (7%, 10% and 13%) and temperature (15 °C and 25 °C) on the growth of 54 *L. oenos* strains. Results showed that *L. oenos* strains differ greatly in their ability to survive adverse conditions. The lower pH values of 3.6 and 3.8 had a marked negative effect on growth, as did the lower temperature of 15 °C. The higher concentrations of SO₂ and ethanol had the greatest inhibitory effect. However, a synergistic effect was shown when both SO₂ and ethanol were added to the test medium. Based on the results, five strains were selected that were best capable of surviving the adverse conditions studied. These strains will be used for further study for the induction of malolactic fermentation.

WW.2471/08/2/4:

EFFECT OF GROWTH SUBSTANCES ON ALCOHOLIC FERMENTATION. 1983-1988

J.J. Venter

This study was undertaken to determine the effects of cellular ergosterol, unsaturated fatty acid and saturated fatty acid concentrations on the fermentation abilities of four wine yeast strains, viz WE 452, WE 500, WE 14 and WE 372, which are currently being used in the South African wine industry.

Fermentations were carried out at 10, 15 and 20 °C and yeast cell ergosterol, unsaturated fatty acid and saturated fatty acid concentrations were determined after 12, 25, 50, 75, 100 and 125 g/l sugar were fermented (stages 1-6). Specific fermentation rates (g/l sugar fermented day⁻¹/100 mg/cell dry mass) at each of the six stages were calculated and compared with the ergosterol unsaturated fatty acid and saturated fatty acid contents of the yeast cells.

The ergosterol contents of the yeast cells decreased significantly as the fermentations proceeded. The cell ergosterol concentrations were affected by the thermal conditions and lower concentrations were obtained at higher fermentation temperatures. This phenomenon was ascribed to higher growth rates of the yeast cells at the higher temperatures resulting in a dilution of ergosterol as this compound is not produced under anaerobic conditions. Furthermore growth of the yeast during fermentation was related to the ergosterol concentration of the yeast cells. The limiting value was approximately 0.1 mg ergosterol 100 mg dry mass yeast. Yeast strain WE 372 contained more ergosterol than WE 500 at the sixth fermentation stage at a 15 and 20 °C. However, the specific fermentation rate of WE 500 was 38 % and 61 % higher than that of WE 372. These results indicate that a higher ergosterol concentration does not ensure a higher specific fermentation rate.

The unsaturated fatty acid concentration of the yeast cells decreased significantly during fermentation. The rate of decrease was affected by the fermentation temperature. Higher fermentation temperatures sustained higher growth rates resulting in a greater dilution of the unsaturated fatty acid contents of the yeast cells as these compounds are not produced by yeast under anaerobic conditions. At the sixth stage at 20 °C, strain WE 500 contained a smaller concentration of unsaturated fatty acids than strains WE 452 and WE 14. However, the specific fermentation rate of WE 500 at this stage was higher than those of the other two strains, indicating that the higher unsaturated fatty acid concentrations of strains WE 452 and WE 14 were not sufficient to ensure higher specific fermentation rates at the later stages of fermentation in the presence of ethanol.

In contrast to the fatty acid concentration, the saturated fatty acid concentration of strain WE 14 increased significantly as the fermentation proceeded at all three temperatures. During fermentations by yeast strains WE 452 and WE 500, the saturated fatty acid concentration decreased from the first to the second stage whereafter it increased. The final concentrations of saturated fatty acids in these two strains were highest during the sixth stage. The saturated fatty acid concentration of WE 372 did not change much during fermentation. Yeast strains WE 452, WE 500 and WE 14 showed higher saturated fatty acid concentrations at the higher fermentation temperatures. It seemed that the saturated fatty acid concentrations of the yeast cells did not play an important role through the initial stages of fermentation. However, high saturated fatty acid concentrations in WE 500 and WE 452 at the sixth stage correlated well with the highest specific fermentation rates recorded at this stage. On the other hand, strains WE 14 and WE 372 contained lower concentrations of saturated fatty acids and showed lower specific fermentation rates at all three temperatures.

It has been suggested that fluid membranes containing relatively high concentrations of unsaturated fatty acids, might interfere with the movement of ethanol out of the yeast cell. A high intracellular concentration of ethanol will impair fermentation capabilities of yeast. On the other hand, results from this study indicate that high concentrations of saturated fatty acids might well render yeast cells more tolerant to ethanol than their counterparts, enhancing fermentation rates in the presence of ethanol during the later stages of fermentation.

• Technology

WW.2471 52 1 5: GRAPE AND MUST HANDLING OF HIGH QUALITY GRAPES FOR OPTIMUM WINE QUALITY. 1980-1988
L.P. Ellis

The effect of grape maturity, mash treatment (immediate separation and skin contact), must treatment (addition of 25 g hl⁻¹ and 125 g hl⁻¹ sodium bentonite) and fermentation temperatures (12 °C and 18 °C) on the quality of wines made from Kerner, Bukettraube, Weisser Riesling, Harslevelü, Sauvignon blanc and Furmint grapes were studied.

Important factors in the making of wines from these new and less well-known cultivars, to attain optimum quality, were obtained in this study. The effect of mash treatments on wine quality depended on the cultivar and on the maturity level at which the grapes were cropped. Kerner grapes cropped at °B acid ratios of 2.5 to 3.0 produced better wines, whereas a value of 2.3 was best for Bukettraube. In general, skin contact produced wines of higher quality from grapes cropped at low °B acid (2.3), whereas free-run juice on the other hand, produced wines of higher quality at higher °B acid (3.0) ratios. For most cultivars, wines produced at a low fermentation temperature (12 °C) were higher in overall quality than the corresponding wines made at 18 °C.

WW.2471 52 1 6: INVESTIGATION OF THE USE OF PECTOLYTIC ENZYMES IN WINE MAKING. 1987-1988
S. Stevens

Enzymes (Spark-L, Ultrazym, Pectinex 3 x L, Pectinex 1 x L, Pektolase and Coloridase) were added to

crushed destemmed Chenin blanc and Muscat d'Alexandrie grapes, at 15 °C and 25 °C. Two concentrations (5 g/100 kg and 20 g/100 kg) of each enzyme were used. Four hours skin contact was given at 15 °C and 25 °C. The juice yield was measured.

Addition of all the enzymes before skin contact caused an increase in juice yield with little difference amongst the enzymes. The best results were obtained in the case of Muscat d'Alexandrie, where the free run juice yield was increased by 52 % with an enzyme addition of 20 g/100 kg at 25 °C. In most cases 5 g enzyme preparation per 100 kg grapes seemed enough for juice recovery. It seemed as if higher skin contact temperatures caused better juice recovery.

To investigate the effect of enzymes on juice clarification, the same enzyme preparations were added to free run juice of four cultivars at 15 °C and 25 °C, viz Chenin blanc, Riesling, Colombar and Muscat d'Alexandrie. Four concentrations (0,25 g/hℓ, 0,5 g/hℓ, 0,75 g/hℓ and 1,0 g/hℓ) of each enzyme were used. The juice was left to settle overnight at 13 °C.

In each case, the use of enzymes enhanced the clarity of the juice, whereas lower grape-juice temperatures gave better results, thus clearer juice. Higher enzyme concentrations gave clearer juice in the cases of Chenin blanc and Muscat d'Alexandrie juice, but 0,25 g/hℓ were enough to obtain optimum clarity with the other cultivars.

Thus, satisfactory results were obtained with this investigation. There were little differences amongst the enzymes with regard to juice recovery as well as juice clarification and it seemed as if a minimum enzyme concentration was needed in both cases. The best juice recovery was obtained at 25 °C, whereas juice clarification was better at 15 °C than at 25 °C.

WW.2471/52/2/2:

ROUTINE ANALYSES REGARDING THE MICROBIOLOGICAL STABILITY OF WINE.
1979-1988

H.G. Tredoux

No research was done under this facet but the results gave microbiologists an insight into the microbiological problems experienced by the industry. During the duration of the facet certain microbiological problems encountered in the wine industry were investigated by analysing the wines for sterility, carbon dioxide content, malolactic fermentation status and various parameters such as volatile acidity, SO₂ concentration, residual sugar and alcohol concentration. This was done to determine whether a given wine was microbiologically stable, i.e. whether any viable organisms existed in the wine together with any assimilable substrate such as sugar or malic acid.

Since the inception of this project, the number of samples analysed increased from 150 in 1979 to a maximum of 688 in 1981, after which the number of samples decreased steadily to only 88 in 1988.

The decrease in the frequency of use for this service was mainly due to producers that acquired facilities for the analysis of such samples, but also because of an increased awareness of cellar hygiene which leads to less microbiologically unstable wines.

• Chemistry

WW.2471/53/1/6:

THE EFFECT OF WINEMAKING PRACTICES AND PHENOLIC COMPOUNDS ON THE BITTERNESS OF WHITE WINES. 1984-1988

L.P. Ellis

Wines from five vintages, having different phenol levels induced by several vinification techniques, were used in this study. Aspects studied included amongst others, the effect of skin contact at 15 °C and 25 °C and the addition of phenol adsorbing material to wine on wine composition and level of bitterness.

Phenolic composition of wines differed according to grape variety and vinification practice used. Muscat d'Alexandrie wines made with skin contact (5 hours) at 25 °C were more intensely coloured, had a higher pH and higher phenolic levels than wines made with skin contact at 15 °C. The wines prepared at 25 °C were also rated more bitter than equivalent wines prepared at 15 °C. Addition of phenol adsorbing agents to bitter wines did not necessarily lower the bitterness rating of the wines, although they had a pronounced effect on the colour and phenolic levels of the resulting wine.

Statistical methods were used to correlate liquid chromatography and sensory data. Evidence is presented of a UV fraction which may be an indicator of the bitterness in wine.

Several methods for the extraction of phenolic compounds in wine prior to high performance liquid chromatography (HPLC) analysis were evaluated. Sample preparation methods studied included amongst others, extraction with organic solvents, concentration with rotary vacuum evaporation and fractionation by means of Sep Pak C18 cartridges. A HPLC method to separate the phenolic compounds in the extracts on a reverse-phase C18 column was developed.

HPLC analysis of a wine concentrate separated at least 60 substances displaying ultraviolet absorption. The identity of several compounds has been verified by comparing ultra-violet spectra of wine components with the spectra of available standards. The method was applied to the separation and quantification (relative amounts) of phenolic compounds in a variety of white wines. Aspects studied included amongst others, the effect of skin contact and the addition of phenol adsorbing material to wine on wine composition and level of bitterness.

Statistical methods were used to correlate liquid chromatography and sensory data. Evidence is presented of a UV fraction which may be an indicator of the bitterness in wine.

Citrus and subtropical crops

CITRUS

• Physiology

SS.2481/03/1/3:

REGENERATION OF EMBRYOS FROM CHIMERAS OF CITRUS FRUIT. 1984-1987

J.H. de Lange

Branch mutations and fruit Chimeras are much in evidence in *Citrus*, especially so in certain cultivars. A chimera indicates a situation where two or more tissues each with a different genetic constitution are present in a single part of the plant. In South Africa fruit chimeras are especially prevalent in Olinda Valencia sweet orange (*Citrus sinensis* (L.) Osbeck). In most cases chimeras are present in sectorial arrangements with distinct boundaries extending from the stem-end to the blossom-end of fruits.

A fallen fruit from a *Citrus* x *Poncirus* hybrid was found to show sectorial growth of *Penicillium digitatum* with sharp boundaries and extending from the blossom- to stem-end of the fruit. All the other fallen fruit beneath the tree were completely rotten and covered with *P. digitatum*. Different stages of fruit maturation or the presence of resistance factors in the chimerical sectors could be involved in these cases. It is evident that the occurrence of fruit chimeras offers an exciting potential for *Citrus* improvement if techniques could be developed to propagate advantageous chimeras.

Callus was initiated from albedo explants excised from approximately one-month-old Eureka lemon (*C. Limon* (L) Burm. F.) fruitlets by culturing them in 90-min petri-dishes on the same medium as the one used by Murashige and Tucker (1969) in their studies on lemon albedo callus. This callus, however, is very hard and very much different from the soft and friable nucellar callus in which somatic embryogenesis can be induced by galactose, lactose or glycerol treatments (Kochba *et al.*, 1982; Ben-Hayym and Neumann, 1983). Somatic embryogenesis could not be induced in these experiments.

If somatic embryogenesis could be induced in tissues from promising *Citrus* fruit chimeras, an extremely valuable source of plant improvement would become available.

SS.2481/03/2/1:

IMPROVED IMMUNOASSAY TECHNIQUES FOR THE STUDY OF PLANT GROWTH REGULATION IN CITRUS. 1986-1989

J.G.M. Cutting

Successful antibodies were obtained from rabbits using a IAA-BSA conjugate prepared in Germany. This serum has been used to set up a radio-immunoassay for IAA with a measuring range from 100 ng to 0.1 ng. Work on this RIA is now complete and supplies of antibodies are being built up.

A new conjugate for raising antibodies against PP-333 using a metabolite, PP-297, with a carboxyl group has been made and a group of rabbits immunised. This research is being conducted in conjunction with ICI in the United Kingdom.

An ELISA for IAA using monoclonal antibody has been set up. The assay has a measuring range from 0,1 ng to 100 ng. There is no advantage in using the ELISA except for cost.

A successful purification and isolation schedule has been established where the spectrum of hormones requires investigation and solvent partitioning would prove to be unsuitable. The system has been tested on a range of different species and found to be suitable.

A simple methylation procedure has been established in the laboratories which does not require elaborate glassware.

• Nutrition

SS.2481/05/1/4:

POTASSIUM EXPERIMENTS WITH CITRUS ON PROBLEM SOILS. 1977-1987

T.J. Koen

The purpose of this investigation was to determine the leaf N and K levels for maximum yield, optimum fruit size and net income. In practise this generally means a reduction in the N level and an increase in the K level of the trees. Factors affecting these changes were also investigated.

Several field experiments with Valencias were conducted:

1. 5^2 N K-experiment in a "small fruit area", on 27-year-old Valencias, with three replications and three trees per plot.
2. K experiments on problem soils at Letsitele and Addo, in which attempts were made to increase fruit size by increasing the K levels in the tree by KNO_3 sprays and soil application of K_2SO_4 KCl.

In the NK-experiment results were obtained over a period of six seasons. It was shown that maximum yield did not necessarily ensure maximum income in an area known for small fruit. It was also evident that the N:K ratio in the leaves of fruit bearing twigs was more important in determining yield or fruit size than the absolute N or K values. In the case of maximum yield the optimal N/K ratio was between 2,4 and 3,0 with N higher than 2,1 % and K higher than 0,8 %. For maximum fruit size the ratio was between 1,6 and 2,2 with N higher than 1,8 % and K higher than 0,9 %. Therefore, to obtain maximum yield the N level should be relatively high and to obtain optimum fruit size and income, the N level should be relatively low.

In the K experiments results were obtained over a period of four seasons. It was shown that yield and fruit size could be improved by KNO_3 sprays. Two applications of a 40 g dm^{-3} concentration during the period November to February are essential. The best results were obtained when the N and K status of the trees were relatively low (less than $2,5 \text{ g kg}^{-1}$ for N and less than $0,9 \text{ g kg}^{-1}$ for K).

Potassium nitrate sprays were shown to have very little effect on the K status of the leaves.

• Upgrading

SS.2481/07/1/1:

BREEDING AND SELECTION TO OBTAIN IMPROVED ROOTSTOCKS FOR CITRUS. 1970-1988

H.J. Breedt

New Trifoliolate hybrids were evaluated at Nelspruit, Friedenheim and Addo. Although the plantings in the Transvaal were infected with citrus greening disease, it was still possible to identify the promising hybrids which out-yielded the reference rootstocks (Troyer and Morton citrange). One hybrid, x171 (Hall's Pineapple x *Poncirus trifoliata*), performed equally to or better than the reference rootstock in combination with four scion cultivars, viz Palmer navel, Olinda Valencia, Marsh grapefruit and Ortanique tangor.

The performance of 39 Trifoliolate rootstock selections in combination with Palmer navel were assessed. The best selections in this respect were Trifoliolate 39 (39) and Trifoliolate 48 (469).

Data on tree size of various navel-Trifoliolate and mandarin-Trifoliolate trees were used to calculate optimal tree spacing.

A new rootstock breeding project will be registered.

SS.2481/07/1/2:

BREEDING AND SELECTION TO OBTAIN IMPROVED CITRUS CULTIVARS. 1974-1986
H.J. Breedt

During 1974 a facet was initiated at Nelspruit to breed Blackspot-resistant lemons, sweet orange cultivars and easy peeler cultivars.

Twenty-two grapefruit and 16 navel hybrids were selected as potential cultivars. The most promising hybrids will be evaluated on several citrus rootstocks in various climatic areas.

It was demonstrated that extensive embryo abortion took place after cross pollination using irradiated pollen but fertilisation and/or early ovule development stimulated set and growth of fruitlets. Ovule occupation by irradiated pollen largely prevented fertilisation by normal pollen.

Pollination, using 0,5 or 1,0 kGy-irradiated pollen followed one day later by a second normal pollination is suggested for further studies on possible transformation of hybrids by the first pollen parent. Seed production after pollinating with pollen irradiated at high doses in a single pollination was very low.

• *Virology*

SS.2481/12/1/1:

BASIC STUDIES ON TRISTEZA VIRUS OF CITRUS. 1976-1989

R.P. Collins

The object of this group of investigations was to conduct basic research on citrus tristeza virus (CTV) in directions which had not been adequately tested in South Africa, including aspects such as purification, serology and strain relationships.

Methods for the bulk purification of CTV from citrus material were successfully developed and used for the introduction of mild isolates of CTV from U.S.A. for cross protection evaluation.

Using purified CTV, antibodies were produced from rabbits and chickens. An ELISA system was developed and optimised for CTV detection. This system is routinely used in CTV indexing at various stages of the Citrus Improvement Programme.

Also using the ELISA technique, it was found that CTV in South Africa is distributed evenly throughout the tree, as opposed to the situation in Florida, and in various surveys that nursery infection of rootstocks is fortunately low.

Attempts were made to correlate the severity of isolates with viral inclusion bodies or dsRNA patterns, but were not successful.

• *Pathology*

SS.2481/19/1/1:

CONTROL OF THE GREENING ORGANISM IN CITRUS. 1971-1988

S.P. van Vuuren

Research was aimed at the control of the disease in infected orchard trees by trunk injection of antibiotics. Tetracycline hydrochloride reduced the disease effectively, and investigations were made to increase the effectivity of the antibiotic.

Control of the causal organism must be combined with effective control of its psylla vector. Despite the methods that have been formulated to control psylla, re-infection via the vector still occurred. Therefore, transmission studies were initiated.

Several antibiotics were tested and tetracycline hydrochloride proved to give the best results in controlling greening disease. The effectivity of the antibiotic can be increased by acidification of the solution, extending the period of treatment or high volume injections. Phytotoxicity symptoms occurred but did not cause permanent damage.

Registered insecticides for vector control can be injected in combination with tetracycline hydrochloride.

Transmission studies on the insect vector revealed that re-infection can occur four days after spraying plants with an insecticide although the insecticide was still effective in killing the insect. The vector can acquire the greening organism within one hour of feeding on an infected plant. After eight hours of acquired feeding, the vector was able to transmit greening the following day.

Mechanical transmission studies showed that the organism can be transmitted at a higher rate than previously reported.

The implications of the findings in the transmission studies are that greening disease can spread more rapidly and at a higher rate than previously reported, and as such, control of the insect will have to be highly efficient to contain the spread of the disease after antibiotic treatment.

On certain farms in the Hazyview and Tzaneen areas, strains of the citrus black spot pathogen, *Guignardia citricarpa*, were shown to have developed resistance to benomyl.

These strains were cross-resistant to all fungicides of the benzimidazole group, but fortunately still sensitive to mancozeb.

Reversion to a mancozeb spray programme provided commercially acceptable control, and within two years the resistant strains in the population had dropped to undetectable levels, indicating that the mutation was less fit biologically than the normal benomyl sensitive strains. Recommendations based on alternating fungicides were formulated and promulgated which should preserve the effectivity of benomyl.

A number of new candidate fungicides were field tested but none were found effective.

SS.2481/19/3/4:

FUSARIUM SOLANI AS A PATHOGEN OF CITRUS: PATHOGENICITY AND CONTROL.
1987-1988

N. Labuschagne

A study was made of the role of *Fusarium solani* and *F. oxysporum* as agents of citrus decline owing to root necrosis.

It was found that *F. solani* was the most common fungus associated with root necrosis. In the absence of stress conditions, the fungus establishes itself in and on the roots without causing overt damage. As soon as conditions such as starch depletion, water-logging, high salt concentrations and particularly co-infection by the citrus nematode occur, the fungus switches to an active mode and causes severe root necrosis. This leads to various degrees of damage and even death of the plant.

Indications are that the problem is widespread in South Africa and is associated with citrus blight and the decline of citrus in the Sundays River Valley. Prochloraz drenches reduce fungal incidence but are not an economical form of treatment. Of importance, however, is that where the stress factor is removed, the fungus causes negligible damage, and in many cases this can be more easily achieved.

• Pests

SS.2481/20/1/10:

VECTORS OF THE GREENING DISEASE, OTHER THAN THE CITRUS PSYLLA. 1986-1989
M.A. van den Berg

Insects and mites found in citrus orchards were placed on sweet orange trees infected with greening. After 3 days these were placed on indicator plants. The plants were kept for 6-9 months at 24 °C during the day and 20 °C during the night for development of greening symptoms.

Of the 93 mites and insect species tested, only 1 species, *Aspilocoryphus fasciiventris* (Stal) (Hemimtera: Lygaeidae) may be able to act as a vector of the greening disease. This species, however, are seldom found on citrus and it most likely does not pose a threat as vector of the greening disease.

• Crop science

SS.2481 30 4 1:

NURSERY TECHNIQUES INVOLVED IN PROPAGATION OF CITRUS TREES. 1972-1988
P.J. Müller

Several trials were concluded during the course of this facet:

- Alternative methods for budding citrus trees were investigated. Micro-budding was identified as a good method of citrus propagation.
- The effect of different nematocides on the suppression of citrus nematodes was tested. Temik and Nema-cur gave the best results.
- Different soil mixes have been investigated that may stimulate the growth of citrus trees. The best results were obtained by the following mixes:
 - (a) 2 parts top soil, 2 parts sugar cane pulp and 1 part (coarse) river sand.
 - (b) 1 part sandy topsoil and 1 part sugar cane pulp.

- The transplanting and care of young citrus trees were investigated and described to limit losses during transplanting. The propagation of citrus trees has also been investigated. These trials covered all stages from harvesting and treatment of the seed to the final stage of a nursery tree.
- Foliar fertilisation was tested and the results showed that no foliar feeding is necessary provided that the correct soil mixture is used with a balance of micro- and macro-elements.
- Soil mixtures for the Eastern Cape received attention. Addo topsoil and Vermiculite (1:1) and Addo topsoil and lucerne hay (3:1) gave the best results.
- Methods have been investigated to speed up the propagation of citrus nursery trees. The removal of the seed coat and the use of plastic tunnels were identified as successful methods.
- Several irrigation systems for nursery use were evaluated. Drippers can save up to 48 % of water and the daily water usage of citrus in plastic containers during the hottest summer months in Nelspruit were 0,16 l. This refers to a daily evapotranspiration rate of 6-7 mm.
- The possibility to use burnt charcoal in soil mixtures has also been investigated. It has been found that it can be used profitably provided that leaching is done before use.
- The optimum shade requirement for citrus nursery trees in Malelane was determined.

Before budding there was a preference for light shade, although there was very little difference between the different shade treatments. After budding the necessity of shade increases and 40 and 55 % shade gave the best results.

From a practical view point a single density shade should be recommended. The 40 % shade gave satisfactory results before and after budding and less water was used than in other shade densities.

PINEAPPLES

• Physiology

SS.2482/03/1/2:

CLONAL PROPAGATION OF PINEAPPLES IN VITRO. 1984-1988

Mariana Fitchet

The purpose of this study was to investigate and establish a method of cloning new superior cultivars or disease-resistant plant of *Ananas comosus*.

Lateral buds from the pineapple crown provided the best ex-plant material for the in vitro culture of pineapples. Successful decontamination was achieved by immersing the ex-plants in 70 % ethanol for 60 seconds, soaking in 0,2 % sodium hypochlorite solution for 15 minutes and then rinsing three times in autoclaved, distilled water.

After sterilisation, the ex-plants were incubated on a medium of Murashige & Tucker (1969) at half the normal concentration. Sucrose at 30 g/l provided the best source of carbohydrate. Organic additives did not improve shoot or root growth.

Naphthaleneacetic acid (NAA) alone or in combination with indolebutyric acid at 1-2 mg/l supported the best shoot growth and root formation. Higher levels of auxins suppressed growth.

Kinetin (K) at 10 mg/l was highly inhibitory to shoot growth. At 2 mg/l it promoted shoot growth, but was inhibitory to root formation. When used in combination, NAA and K, each at 2 mg/l, provided ideal conditions for shoot growth and multiple shoot formation.

Shoot proliferation in a liquid medium on a platform shaker was superior to that on a semi-solid medium of the same composition. Zeatin yielded better multiple shoot formation than kinetin or benzyl adenine, but owing to the cost factor, kinetin is considered more suitable.

Multiple shoots, as well as "bulbils" or "protocorm-like bodies", were produced. Detached leaves also produced adventitious plants. Multiple shoots were separated and rooted on Murashige & Tucker medium (1969) with 1 mg/l NAA before re-establishment in soil.

The plantlets were acclimatised in seedling trays over which plastic tunnels were constructed. After one to two weeks in the enclosed tray, the plants were transferred to the nursery where they were planted out in black plastic bags.

A viable clonal propagation technique was accomplished and the facet is terminated.

• Pests

SS.2482/20/1/2:

CHEMICAL CONTROL OF PINEAPPLE PESTS: CONTROL OF FRUIT AND FOLIAR PESTS OF PINEAPPLES. 1975-1988

G.J. Petty

Tarsonemid and tenuipalpid mites, *Steneotarsonemus ananas* Tryon and *Dolichotetranychus floridanus*

Banks, respectively, and the mealybugs *Dysmicoccus brevipes* Ckll, and *Pseudococcus longispinus* Targioni-tozetti, associated with pineapple plants, were studied to develop chemical control measures which might be applied to prevent economically important damage to pineapple plants.

For *S. ananas*, a special sampling technique was developed which facilitated the determination of mite distribution on plants and in the plantations, as well as the relationship of mite numbers to leathery pocket disease and effectiveness of all available acaricides. For most forcing months, an increase in mite numbers was associated with greater incidence of leathery pocket. Abiotic factors showing a correlation included land aspect and latitude, herbicides, hormoning follow-up interval, copper, zinc and phosphorus content of plant and fruit and magnesium and phosphorus content of soil. In acaricide studies, 0,05 % endosulfan was superior to any other acaricide. Applied monthly, from 4 weeks before to 12 weeks after forcing, leathery pocket disease was reduced to as much as 88,2 %. A 5-spray programme from 5 weeks before to 11 weeks after forcing gave 88,3 %-90,1 % control.

Controlling *D. floridanus* mites on Queen pineapples in Zululand increased number of fruits by 31,7 %, and yield by 49,1 %. The effect of season, pineapple cultivar and soil type on mite infestation during a 2-year period was studied. Queens on sandy soil were generally most heavily infested, but not on a heavy soil type. In general, mite numbers were lowest from April to September, and tended to fluctuate more on Cayennes than on Queens. The efficacy of two acaricides at different dosages, when applied by knapsac sprayer to small field plots indicated that the systemic organophosphates - monocrotophos, methidathion and dimethoate - are most effective. Spray volumes should exceed 1 000 l/ha but 2 000 l/ha was as good as higher volumes up to 4 000 l/ha.

P. longispinus mealybug infestation reduced fruit yield by 11,7 % and increased black spot in fruit by 121,6 %. Planting material dips for mealybug control were evaluated in both laboratory and field trials. Diazinon, methidathion and dimethoate were most effective, but plants remained uninfested for only 2 months.

The importance of *D. brevipes* mealybugs was indicated by the increasing number of mealybugs on plants showing progressively more severe symptoms of plant degeneration, and a 28 % black spot incidence in fruit on infested plants and 0 % for uninfested plants. In these *D. brevipes* studies, the number of mealybugs on the 10 lowest (oldest) leaves of each plant were determined as it was found that, on average, 88,1 % occur here.

The effect of pineapple cultivar, soil type, season and rainfall on mealybug populations was studied. Infestations were high for a few months after planting in October, and for 5 months from the following May/June. Periods of high rainfall were associated with low infestations. The Queen cultivar was generally more heavily infested, but soil type does not appear to affect infestations.

For corrective control of *D. brevipes*, the following strategies were investigated:

- (a) Planting material sanitation
- (b) Pre-plant soil treatment with granular systemic insecticides
- (c) Foliar spraying of established plantings with insecticides
- (d) Ant control.

The most effective chemical strategy was fumigating tops or suckers with methyl bromide gas at 40 g m⁻³, or 32 g m⁻³ (depending on ambient temperature) for 2 hours. 100 % disinfestation was obtained, which persisted for up to 17 months. A combination of plant and soil fumigation with methyl bromide increased fruit yield by 168,2 %. As a result of this facet, mercaptothion, diazinon and dimethoate were registered for mealybug control. Systemic granulars, particularly carbofuran and phenamiphos reduced infestations up to 8 months. For ant control the bait-toxin Amdro at 1-2 kg formulation per ha gave excellent control for up to 5 months. This could have a favourable effect by suppression of mealybugs by natural enemies.

• Crop science

SS.2482/30/1/4:

EVALUATION OF MULCHES FOR PINEAPPLES. 1978-1988
E.R. Dalldorf

The object of this research was to determine the value of plastic sheeting, co-polymer emulsions and pineapple plant material mulches on the growth and yield of pineapple plants in South Africa.

Plastic mulches of 100, 50 and 40 micron were evaluated in numerous trials. Plastic mulches of all thicknesses improved plant growth and yields. However, yields and plant growth could vary greatly according to:

- (a) climatic conditions prevailing during the cycle of the pineapple growth;

- (b) area in which plantings took place; and
- (c) aspect of planting (northern or southern slope).

A number of disadvantages were encountered:

- (a) Heavy rains and winds just after laying the plastic could result in excessive damage to the planting (when planted on ridges) by the lifting of the plastic.
- (b) Soil preparation requirements are more exacting, hence extra preparation costs, and the cost of 40 micron plastic (R690/ha) reduce the benefits greatly.

The use of organic material in the form minimum tillage proved to have many cultural disadvantages in that pre-plant fumigation and ridging is not possible. The retention of moisture by minimum tillage, and the destruction of ridges lead to serious *Phytophthora* problems. It is, therefore, essential to apply the recommended control measures should such a cultural practice be used.

Co-polymer emulsion applications were not found to benefit the herbicide residual effect, plant growth, yields, increase the effect of pre-plant fertiliser, or increase fruit sugar content.

This facet proved the most effective form of mulching to be plastic sheeting. However, as in Australia, it is doubtful whether this form of mulch will ever be used on more than a limited scale.

AVOCADO

• *Physiology*

SS.2483/03/1/4:

RADIOIMMUNOASSAY TO DETERMINE THE HORMONAL STATUS OF ETIOLATED
AVOCADO STEMS. 1981-1989

J.G.M. Cutting

Gibberellin was injected into several small nursery trees to induce a "juvenile" vigour in the subsequent growth flush. The resultant vegetative flush was vigorous and showed diminished apical dominance.

After hardening off, cuttings with at least 2 leaves were taken, treated with IBA and placed in a mist bed with bottom heat. Cuttings showed rooting after 120 days. Percentage rooting in the case of 'Duke 7' was 68 %. The technique was not successful with 'Martin Grand'.

SS.2483/03/2/2:

DEVELOPMENT OF SHOOT TIP GRAFTING TECHNIQUE IN AVOCADOS.

M. Nel

The shoot tip grafting technique as developed for citrus was used as a basis for the work on avocados. However, problems primarily of a physiological nature (mainly tissue browning) resulted in modifications in an attempt to prevent tissue degeneration.

Suitable shoot tips for shoot tip grafting (STG) are only available for short periods during the season, but shoots were cultured *in vitro* to solve this problem.

Problems were also experienced with establishment of rootstocks for STG. After several experiments, aseptically dissected embryos were cultured *in vitro*, in darkness on a paper bridge over a liquid medium at 27 °C. After 2 weeks the etiolated rootstocks were 10 to 20 mm long and ready for STG.

Several problems were furthermore experienced with the grafting process. In addition to the fact that STG is a very time consuming and delicate process, all cuts were done under sterile water to reduce phenolic browning. Rootstocks were submerged for 24 hours to ensure a better cut surface for STG. Shoot tips were submerged overnight in a solution containing 1 mg/ℓ soluble PVP-powder and 1 % Agar to reduce phenolic browning. The graft was covered with a solution of insoluble PVP (Polyclar AT) and "Lanolin" (sheep's woolfat) to prevent dessication of the graft.

Little success was attained with the establishment of STG plants in the soil under aseptical growth conditions. The possibility of grafting the STG plants onto established seedling rootstocks was investigated, without success. The delicate STG plants repeatedly dessicated and died off, mainly because of the meristematic cells in the cambium layers that did not fuse properly.

As a result of above-mentioned problems, it was recommended that this facet should be terminated.

• *Upgrading*

SS.2483/07/1/1:

SELECTION OF ROOTSTOCK/SCION COMBINATIONS IN AVOCADOS. 1985-1988

B.J. Durand

This study was aimed at finding a method to identify excellent avocado trees in terms of production and

survival in *Phytophthora* infested orchards. At the same time the study was aimed at finding better producing selections of existing cultivars in order to increase production per unit area in the avocado industry.

The method selected was to record individual tree yields in commercial orchards of different cultivars in different geographic areas of South Africa. A number of growers participated in the study but only one grower submitted data for all four seasons. Production maps were produced that reflect the yield of every tree in the orchard. Cumulative production maps were produced after every new year's data was obtained to establish which trees produced the best in the long term. Annual yield records were used to analyse the pattern of yielding for every promising tree.

Two types of trees were identified that could be considered for selection. The first type yielded very well in the long term but yielded well only in alternate years. The other type yielded well every year although some variation occurred from year to year. The consistent bearing habit is preferable but the high cumulative yields of "alternate" bearers precluded their exclusion from the selection process.

Owing to the short record of only four years no selections have been specifically identified as being superior. This study indicated that the recording of individual tree yield records has value as a management tool as non-productive trees were culled from the orchards without reducing yield but reducing maintenance cost of the orchards by a significant margin.

It can be concluded from this study that the selection of the best producing trees of existing cultivars, as well as breeding of new cultivars are high priorities.

• Pathology

SS.2483/19/1/3:

CHEMICAL CONTROL OF AVOCADO ROOT ROT. 1972-1990
J.A. Herbert

The aim of this project was to develop chemical control measures for avocado root rot. At the start of the project, only pre-plant fumigation was known to be effective and then it was only effective for a few years before recolonisation took place and the disease cycle resumed.

During the early stages of the study, numerous chemicals were tested in vitro and as pre- and post-plant treatments. A number were shown to have in vitro activity against *Phytophthora cinnamomi* and a simple soil tube test showed a few to have potential as post-plant drenches. Of these only metalaxyl (Ridomil, Ciba-Geigy) was eventually registered, the others being withdrawn by the manufacturers or proving to give unsatisfactory control in the field.

At the close of the project metalaxyl is still registered and is effective. Where it has been used continuously a loss in efficacy has been seen and it is recommended that this chemical not be used for more than two consecutive years. Its main use is now in nurseries and young plantings.

The other chemical to be registered during the course of the project was fosetyl-Al (Aliette, MayBaker). Originally this was used as a foliar spray applied six times a year. The spray regime gave a positive, if slow response and a disadvantage was that trees in an advanced stage of defoliation did not respond well to treatment owing to restricted uptake of the chemical.

A method was developed for extracting and injecting the active ingredient. This gave a quick response, but entailed critical preparation of the injection mixture, which led to variable results in the field. An injectable formulation at a constant 10% level of a.i. was developed by the manufacturer. Numerous field trials showed this to be a most effective remedy and it is now in widespread use in the industry. No reports of loss of efficacy of this chemical have been received.

Presently, *Phytophthora* root rot of avocados is under very effective control by fosetyl-al and metalaxyl. There is a danger in relying on chemical control of such a damaging disease and research effort is now directed towards identifying tolerant rootstocks which will provide a lasting solution.

BANANAS

• Pathology

SS.2484/19/1/1:

CONTROL OF PANAMA WILT OF BANANAS. 1973-1989
J. Herbert

Panama Disease (PD) or Fusarial wilt is the most important disease of bananas in South Africa. Attempts were made to find a means of controlling it by chemical, biological and cultural means. A search for resistant cultivars was also part of this facet.

Many chemical treatments were used to try and suppress the disease. These included spraying, stem injections, drenching and fumigation. Of all treatments only methyl bromide fumigation at 100 g m² gave any reduction in disease incidence. Certain of the injection treatments delayed symptoms expression.

Biological control measures, using antagonistic fungi and non-pathogenic *Fusaria* were unsuccessful.

Some cultural methods such as the placing of uninfected soil in planting holes delayed the appearance of symptoms but did not give any significant control over time.

Containment measures were successful where they were rigorously applied.

The failure to affectively and economically control the disease in the field has led to the conclusion that the only answer to the problem lies in the development of tolerant cultivars with acceptable fruit quality. Most imported cultivars, reputed to be tolerant, but one, SH 3362 showed a high level of tolerance. Unfortunately fruit from this cultivar was not commercially acceptable.

As biotechnological techniques become more sophisticated it may be possible to transfer this resistance to the present commercial cultivars. A Panama Disease Research Unit has been created with the primary objective of producing resistant, commercially acceptable banana cultivars. It will also assume responsibility for all other aspects of Panama Disease research.

• *Crop science*

SS.2484/30/1/2:

CROP TIMING AND FORECASTING WITH BANANAS IN RELATION TO TIME OF PLANTING, SUCKER SELECTION, SPACING AND LOCALITY. 1980-1988

J.C. Robinson

In the main crop timing trial at Burgershall, bananas planted in March were harvested during the undesirable spring period, and this effect was largely carried over into the R1 and R2 cycles. December planting was optimal and September planting intermediate from a crop timing viewpoint. Cumulating all 3 crop cycles, 50 % of the total bunch harvest could be timed during autumn from a December planting and at a density of 1 666 plants/ha. From a September planting, the proportion of autumn-harvested fruit could also be increased from 2 %-20 % by increasing the density and by delaying the selection of the first ratoon sucker until at least 10 months after planting.

At Levubu, results were substantially similar to those from Burgershall as far as crop timing was concerned. From a December planting, 38 % of the total harvest of 3 crop cycles occurred during autumn. From a September planting, the proportion of autumn-harvested fruit increased from 1 %-11 % with the higher density and late sucker selection.

Repeated banana plantings, conducted annually in September, December and March at Burgershall and Levubu, have demonstrated that in respect of timing the plant crop, variations from year to year were very small (cv of mostly under 5 %). Thus, prediction of harvest date from planting date can be made accurately, irrespective of year. Variation in bunch mass was much higher, therefore, bunch mass and yield potential cannot be reliably predicted in advance (cv from 10-22 %).

Banana crop forecasting programmes have been compiled and computerised for use by the Banana Board. Separate programmes exist for Williams at Burgershall, Williams at Levubu and Dwarf Cavendish at Burgershall. The programmes are being tested experimentally on flower counts made by members of the Levubu and Burgershall banana study groups. This will establish any practical problems or refinements needed, and will evaluate the accuracy of the forecasting model under commercial growing conditions.

In the desuckering trial at Burgershall, results demonstrated that poor desuckering (leaving suckers to 800 mm before removal) reduced R1 yield/annum by 18 % and R2 yield by 17 %. Results also showed how management can influence crop timing. With poor desuckering, a 2-month delay occurred in the total cycle time of the R1. Another one-month delay occurred from harvest of R1 to harvest of R2. Thus, a crop timing programme based on planting date, must depend on all general management aspects being uniform and optimal.

• *Water requirements*

SS.2484/31/1/1:

INVESTIGATION OF IRRIGATION SCHEDULES AND SYSTEMS FOR BANANAS. 1980-1988

J.C. Robinson

There was an increasing yield response to daily drip irrigation up to a crop water use coefficient of 0.75 in a dry, hot year (R1 cycle). In two years of higher rainfall with lower evaporative demand (R2 and R3 cycles), there was an increasing yield response only up to a water use coefficient of 0.5. Therefore, since the

evaporative demand of a season cannot be known in advance, the evaporation pan is not a reliable schedule indicator in the subtropics and must be supplemented with soil moisture determinations.

Drip irrigation proved superior to undercanopy sprinkler irrigation over 3 ratoon cycles (31, 33 and 9 % increase in yield annum for R1, R2 and R3 cycles, respectively). Most of the increase was due to a shorter crop cycle time with drip irrigation, in which no evaporative cooling occurred to slow down plant growth.

There was no consistent yield difference between low depletion irrigation (16 % depletion of TAM) compared to high depletion (80 % depletion of TAM). This is because high depletion did not increase soil moisture tension to stress levels in this trial, and secondly, the frequent irrigations at low depletion tended to cool the plants, causing slower growth.

From gravimetric analysis, seasonal crop factors varied from around 0,6 in winter to 0,9 in summer. Consequently, a lower proportion of the evaporative potential was transpired in winter, which was related to the cessation of root extension growth and an absence of feeder roots. Crop factors in autumn and spring were intermediate, but were higher in autumn owing to a larger leaf area than in spring. Extraction patterns indicated that 80 % of the total water lost from the root profile occurred from 0 to 300 mm soil depth.

Short cycle irrigation is still strongly recommended for bananas. However, this should not be applied by a system which frequently cools the plants down, e.g. overhead sprinkler. Furthermore, soil moisture tension should be used to monitor the irrigation requirements in order to prevent under-irrigation in a hot dry year, or over-irrigation in a mild rainy year.

DIVERSE SUBTROPICAL FRUITS

• Anatomy

SS.2485/02/1/2:

REPRODUCTIVE BIOLOGY OF VARIOUS SUBTROPICAL FRUITS: MANGO. 1983-1989
P.J. Robbertse and Esme de Wet

The mango cultivar Haden is traditionally a poor yielder. In this project we looked at the sexual reproductive cycle as a possible causative factor for poor fruit set. Pollen quality and functioning, as well as ovule structure and functioning of Haden, was compared with Sensation and Zill.

Pollen dehiscence is controlled by temperature and relative humidity. Conditions were, therefore, manipulated to obtain fresh pollen for in vitro, semi vivo and in vivo pollinations. Temperature regimes during pollination are critical. The optimal temperature for pollen germination and pollen tube growth is between 25-30 °C, provided the boron content of the pistil is about 80 ppm. Haden is partly self-incompatible, and better results were obtained where Zill and Sensation pollen was used to pollinate Haden pistils.

The mango has a pachychalazal ovule and penetration of the pollen tube is chalazal. A high percentage of abnormal embryo sacs were found in Haden which could explain the high percentage of early fruit drop in this cultivar.

SS.2485/02/1/3:

FLOWER AND FRUIT DEVELOPMENT OF DIVERSE SUBTROPICAL FRUITS WITH
RELATION TO PAPAYAS. 1985-1988
A.D. Sippel

The aim of this facet was to take an in-depth look at the problem of malformed fruit and to try and find solutions to the problem. This facet dealt with the following subjects: fruit-bud differentiation, micro-sporogenesis and -gametogenesis, mega-sporogenesis and -gametogenesis, embryology, fruit growth and fruit malformation.

The development of the various petal whorls occurs normally. The hermaphrodite ovary is differentiated at a flower length of 6 mm and the female ovary at 3 mm. Flower differentiation in the 'Sunrise Solo' papaya occurs nine to ten weeks before full flowering. The stage of development should not be correlated with the number of leaf axils from the growth point. For this purpose a flower at full flowering should be taken as reference, and should then be numbered according to the phyllotaxy. In South Africa fewer flowers are formed over a given period than in Hawaii because of limiting climatic conditions. A mean of 1,5 leaves are formed per week.

Microsporogenesis also occurs normally. Reduction divisions occur in both hermaphrodite and female flowers at a mean flower length of 6 mm. Pollen is mature 25 to 30 days before full flower.

The ovule is anatropous. The inner integument is formed either before or at the same time as the outer integument. Differentiation begins before the megaspore mother cell has formed. A tetrad is formed of which the chalazal megaspore remains functional. A polygonum monosporic embryo sac is formed. The antipodals disintegrate soon after formation and are seldom observed.

Pollination occurs in hermaphrodite flowers before flower opening. UV-fluorescence microscopy may be used to study fertilisation and to determine the rate of pollen tube growth. An interesting occurrence is the thickening of the pollen tube tip as it enters the micropyle and nucellus. Fertilisation occurs about 10 days after pollination. It is, however, affected by distance of the ovule from the stigma. As a result of this, ovaries within a fruit are observed in different stages of development.

Two-celled pro-embryos were observed 30 days after full flowering, and heart-shaped embryos 140 days after full flowering. The embryo follows an Onograd-type development. Divisions of the embryo could not be determined with absolute certainty. The endosperm is free nucleate. Seventy to 140 days after full flower the endosperm starts with cell wall formation. Specialisation occurs in the nucellus at the chalaza which indicates a possible nutritional function of the tissue. The nucellus retains a degree of contact with the embryo until the endosperm formed cells.

'Sunrise Solo' papaya fruit exhibits a single sigmoid growth curve. An increase in rate of growth is observed shortly after full flower, indicating the beginning of fruit growth. Fruit malformation seems to be caused by the fusion of the filament with the carpels. The cause of this is not known. The highest percentage ripe fruit that showed malformation occurred during May, indicating that fruit setting during the winter and early spring months are susceptible. Cold climate, therefore, plays a role in the production of malformed fruit.

Trials of the second part of this facet concentrated on the development of the fruit at different times of the year. This would have given a growth curve whereby the influence of climate on fruit growth could be determined. Climatic data was also accumulated to try and find a causative factor. Deformed flowers and fruit were to be collected throughout the year on which anatomical studies would have been done. Leaf samples were also collected on a weekly basis to look at the effect of cold injury thereupon.

Owing to the termination date (September) of the facet, insufficient material was collected on which anatomical studies could be performed. Furthermore, the decline of the orchard, and also the effect a hailstorm had on the data trees, resulted in the termination of material and data gathering.

• *Physiology*

SS.2485/03/1/1:

FLOWER AND FRUIT DEVELOPMENT STUDIES IN SUBTROPICAL FRUITS: MANGO.
1982-1988

P.D.F. Mullins

This study aimed to investigate the effects of low temperatures on floral development and behaviour in mango so that crop losses could be avoided.

Flower delaying trials were conducted on 'Sensation' and 'Haden' mango trees near Malelane in the eastern Transvaal lowveld. During 1983/1984 the treatments included an untreated control, hand deblossoming at full panicle expansion, the latter followed by an ethephon spray (200 mg kg⁻¹), two concentrations of GA₃ (10 and 20 mg kg⁻¹) at the beginning of June, and two concentrations of cycloheximide (125 and 250 mg kg⁻¹) sprayed at peak flowering. In the 1984/1985 season dinoseb acetate (5 000 mg kg⁻¹) sprayed at 100 mm and 200 mm panicle expansion replaced the cycloheximide. The concentration of the GA₃ sprays was increased to 100 mg kg⁻¹.

Hand deblossoming was the most effective treatment by delaying flowering by 8 weeks, and during 1983/1984 in 'Haden' resulting in significantly higher yields (16,5 t ha⁻¹) compared to control (3,5 t ha⁻¹). This was attributed to the higher temperatures during the delayed flowering time compared to the normal flowering time (mean minimum temperatures 13,3 °C and 7,6 °C, respectively). Cycloheximide sprays at both concentrations showed excessive foliar phytotoxicity, especially in 'Sensation', but did not result in rapid panicle senescence. The GA₃ sprays inhibited flowering when applied before flower bud initiation, and the addition of the ethephon spray to the hand deblossoming treatment failed to hasten reflowering. Dinoseb acetate applied at 200 mm panicle expansion resulted in rapid panicle senescence leading to a second flowering flush 6 weeks later. During 1984/1985 no benefit was gained from delaying flowering because of higher minimum temperatures compared to 1983/1984.

The time of initiation and duration of differentiation of 'Sensation' and 'Haden' flower buds were investigated in Malelane, Nelspruit and Levubu. In Malelane, initiation began in both cultivars at the end of May, in Levubu in the last week of May and the first week of June, and in Nelspruit during the second week

of June. Differentiation occurred over 4 weeks in 'Haden' and 6 weeks in 'Sensation' at Malelane. At Levubu differentiation occurred over 6-7 weeks in both cultivars, and in Nelspruit over 7 weeks in 'Haden' and 8 weeks in 'Sensation'. It was concluded that the time of flower bud initiation was influenced not only by the onset of cool conditions at the end of May, but also by the time of cessation of shoot, and probably root growth before the onset of winter. The rate of differentiation was stimulated by higher temperatures.

The anatomical development of the hermaphrodite flower was studied in relation to growth and time before anthesis. The first significant changes occurred some 12-13 days before anthesis with the meiotic division of the microspore mother cells. The development of the flower was more rapid than expected and this study will provide a valuable grounding for further work on the effect of low temperatures or stress conditions on flower development.

Flower behaviour of 'Haden' and 'Sensation' was studied during early normal (EN) flowering, late normal (LN) flowering, and delayed (D) flowering. Mean daily variation in temperature, relative humidity and saturation vapour deficit were recorded during each flowering time. During EN flowering, anthesis occurred at a constant low rate (20 to 30 %) from 08h00 to 14h00 and then dropped to 10 % at 16h00. During LN and D flowering times, 60 % of flowers had opened before 08h00. Initiation of dehiscence occurred at 12h00 during EN flowering, at 10h00 during LN flowering and at 08h00 during D flowering.

Percentage pollination of random samples of flowers collected during EN (14 % in 'Haden' and 18,31 % in 'Sensation') and significantly lower than during LN (34,5 % and 40,5 % in 'Haden' and 'Sensation', respectively) and D (43,2 % and 49,9 % in 'Haden' and 'Sensation', respectively).

It was postulated that temperatures rising above 19-23 °C, and SD above 10 to 19 hPa result in the initiation of anther dehiscence. Such conditions should occur before 10h00 to improve synchronisation between anthesis and anther dehiscence, which providing that sufficient pollinating insects are available, should allow for sufficient pollen transfer to occur.

It was concluded that although these studies at first appear unrelated, they combined to provide valuable information for the mango industry. Delaying flowering may be beneficial if mean minimum temperatures during normal flowering are lower than 8 °C. Hand deblossoming is not practical, however, but the use of dinoseb acetate (5 000 mg kg⁻¹) may have potential. Two sprays could be used, one to control early developing panicles and a second some two weeks later to control later developing panicles.

The work on flower delaying, and on flower bud initiation and differentiation provide valuable information for research work on mango pruning. A pruning treatment, if timed correctly, could control tree size as well as delay flowering.

The results of the work on flower behaviour provided more information to the farmer to assist with the decision to delay flowering or not and also provides additional parameters for climate selection for mango production.

SS.2485/03/2/5:

DIVERSE SUBTROPICAL FRUIT: DEVELOPMENT OF TISSUE CULTURE TECHNIQUES FOR THE PRODUCTION OF EMBRYOGENIC CALLUS, PROTOPLASTS AND HAPLOID PLANTS IN PAPAYA. 1985-1989

G.W. de Winnaar

This facet comprised the development of a protocol for the establishment of embryogenic callus and protoplasts, with a view to in vitro selection for disease resistance. The development of haploid plants would be advantageous for future breeding and in vitro selection.

Callus was established from immature ovules, as well as from seedling explants. Various induction media were evaluated and callus was subcultured regularly to promote growth thereof. Finally, cultures were induced to differentiate by various treatments.

Callus could be induced from immature ovules of open-pollinated papaya fruits, on a basic low salt medium with 400 mg l⁻¹ glutamine, 20 % coconut water and 6 % sucrose. Growth of the callus was, however, poor. Upon subculture to an embryogenesis medium with 20 % coconut water, somatic embryos were formed in one of 80 cultures. Development of these embryos was stimulated by the same medium, without further subculture. The rest of the cultures could not be differentiated even after transfer to media containing substances that promote embryogenesis. No further attempts to establish callus from ovules were made, since it was concluded that cross-pollination of fruits with another *Carica* species was necessary to ensure a positive in vitro reaction.

Callus from seedlings was initiated from seedling explants that were raised aseptically. Seedling stem and root segments, as well as shoot tips, mostly formed callus. In the case of leaves, callus only formed when adaxial leaf surfaces were in direct contact with the nutrient medium. However, most of the seedling explants also directly gave rise to roots. This could be suppressed by addition of GA₃ or 0,4 % activated charcoal to

the medium, or by lowering the NAA concentration of the medium, but in the case of activated charcoal, induction and growth of callus was also suppressed.

Callus induction as well as subsequent growth was best on a medium with 1 mg/ℓ casein hydrolysate, 160 mg/ℓ adenine sulphate, 1 mg/ℓ NAA and 0,5 mg/ℓ kinetin. When incubated on this medium, explants also formed less roots.

After the first subculture of the callus to the various induction media, callus from stem segments gave rise to shoots in several cases. After a second subculture on an initiation medium without GA₃, a root culture also differentiated and somatic embryos were formed. Apical development of these embryos was later observed on the same medium. Although callus in the preceding cases differentiated spontaneously, no further organogenesis or embryogenesis could be induced by media treatments. Growth and proliferation of the callus was also mostly poor.

In spite of the various media that were evaluated, proliferation and maintenance of callus could not be obtained. The aim - manipulation of callus for in vitro selection - could thus not be attained, since no stable cultures could be established from juvenile seedling material. As the technique for protoplast culture is based on the perfection of these principles for callus production no protoplasts were cultured.

Anther cultures were established to obtain haploid plants. Anther cultures, containing microspores in different developmental stages, were established on various media. Conditioning of these cultures by a cold pre-treatment was also evaluated. However, the development of plantlets from the microspores could not be stimulated and it was concluded that the physiological state of the donor plants was not optimal, resulting in the poor in vitro reaction of the anther cultures. Since anther culture involves a specialised technique and no suitable donor plants were available, no further cultures were established and the facet was terminated.

• Pathology

SS.2485/19/1/1:

DISEASE OF DIVERSE SUBTROPICAL FRUITS: LIFE CYCLE AND CONTROL OF BACTERIAL BLACK SPOT OF MANGOES. 1972-1988

A. Oosthuizen

Nature and extent

This study was aimed at improving the existing control measures through the testing of bactericides and through obtaining an understanding of the life cycle of the organism and the influence of environmental factors thereupon.

Results

During the course of this long study all available chemicals for the control of bacteria on tree crops were tested in the laboratory, and the better ones in the field.

None of these controlled the disease better than copper containing chemicals, which alone by themselves leave much to be desired.

The disease is caused by *Xanthomonas campestris* pv. *Mangiferae indicae* which is essentially a wound pathogen. The optimum temperature for infection lies between 18 and 26 °C. New field infections are positively correlated with rain, wind and pre-existing infection levels.

The use of cardboard canopies on fruit is effective in preventing infection, but not practical. Regular sprays of copper-based products and the use of tolerant cultivars are the only control measures. Wind breaks are expected to reduce the severity of infection.

Artificial inoculation of leaves under field conditions gives a rapid assessment of tolerance of new cultivars.

• Pests

SS.2485/20/1/2:

OCCURRENCE AND CONTROL OF PLANT-PARASITIC NEMATODES IN MANGOES. 1986-1988

P. Willers

A survey was carried out in the 4 main mango producing areas in South Africa to determine the nematode species present and the population numbers in mango orchards. The correlation between nematode numbers

of a spiral nematode population and degree of mango tree decline was investigated. The effect of the systemic nematocides on nematode mortality and tree response was determined.

The survey indicated the absence of important nematode parasites of subtropical crops e.g. *Meloidogyne* (root-knot nematode) and *Radopholus* sp. (burrowing nematode) in mango orchards. Ten nematode species were found associated with mango trees as new recordings. The most important nematode parasite of mangoes in many overseas producing countries, *Hemicriconemoides mangiferae*, was absent from local mango orchards in the areas surveyed. This species is, however, common in litchi orchards probably owing to wrong nursery practices of the past.

Positive correlation could be demonstrated between nematode numbers and degree of mango decline based on a visual scale ranging from 0 (healthy) to 5 (severely declined).

Fenamiphos applied at rates of 40 g ai and 1,3 g ai during March (post-harvest) and September (full blossom), respectively, had no influence on yield nor fruit size in a 6-year-old Sensation mango orchard despite sound nematode control. Aldicarb applied as fenamiphos at rates of 4,5 g ai and 1,5 g ai/m² provided the same degree of nematode control without any tree response.

It is concluded that the nematode species common in mango orchards at the present numbers do not warrant control measures. This favourable situation should be maintained at all cost by limiting the dissemination of *Hemicriconemoides mangiferae*, particularly in mango producing regions.

• Crop science

SS.2485/30/2/1:

TESTING OF DIVERSE SUBTROPICAL FRUITS IN DIFFERENT LOCALITIES. 1975-1988
A.J. Joubert

The objective of the study was to determine the potential and adaptability of various subtropical fruits in different localities in South Africa. Trial plantings of these fruit crops were established in the non-traditional subtropical fruit growing areas of Transvaal, Natal and the Eastern Cape. From the performance of the different fruit crops it was possible to draw certain conclusions.

It has been found that a number of diverse subtropical fruits have the potential to be commercialised, i.e. carambola, jaboticaba, feijoa, custard apple, natal plum, surinam cherry, white sapote, kei apple, coconut, cashew nut and cacao.

In the northern Natal area at Makatini, coconut and cashew nut performed well. Other promising crops for the area are pepper, bixa, banana, litchi, papaya and granadilla. From a survey it appeared that the Natal coastal area is suitable for a range of subtropical fruit crops and that there is a potential market for these fruits. The major limiting factors are, however, competition with existing crops, the size of farm units and limited irrigation water in some areas.

The far northern Transvaal is suitable for mango, papaya and yellow granadilla. At Vaalwater granadillas are grown commercially with mangoes and guavas as suitable alternative crops. At Levubu a large variety of subtropical fruits are grown commercially, i.e. banana, avocado, litchi, guava, pecan and macadamia nuts.

None of the subtropical fruits tested have the potential to substitute citrus as a commercial crop in the eastern Cape. The biggest potential of these fruits is to supplement citrus in well-chosen localities where frost damage will not be a problem. Mango and macadamia nuts performed poorly and the area is marginal for avocado and papaya. Small scale plantings of guavas, pecan nuts and granadillas could be considered.

• Chemistry

SS.2485/53/1/1:

NATURE AND RELATIVE OCCURRENCE OF FACTORS AFFECTING GROWTH IN
MANGO FLOWERS WITH MALFORMATION. 1986-1989
B.Q. Manicom

The project was a study of the underlying biochemical causes of the physiological abnormalities in malformation with the aim of formulating control methods.

Three-fold higher levels of endogenous cytokinins were found in malformed inflorescences as compared to healthy flowers. Qualitative differences also existed, in that trans-zeatin (Z), dihydrozeatin and ribosyl-dihydrozeatin, present in healthy inflorescences, were not found in malformed inflorescences. The reverse applied to iso-pentenyladenine (IPA) and iso-pentenyladenosine (2IP).

Fusarium subglutinans, the causal organism of the disease, synthesises trans-zeatin, trans-ribosylzeatin and iso-pentenyladenine from adenine. No synthesis of auxins could be detected.

Further feeding studies showed that the fungus interconverted Z and IPA and 2IP.

It is suggested that the action of the fungus by causing an imbalance between zeatin derivatives and IPA and 2IP leads to the formation of malformed inflorescences. This could be tested by blocking the conversion to IPA and 2IP, or by adding zeatin compounds to the system to restore the balance.

OTHER SUBTROPICAL CROPS/ANDER SUBTROPISCHE GEWASSE

• Pests

SS.2486/20/2/1:

OCCURRENCE AND CONTROL OF ROOT-KNOT NEMATODE SPECIES (*MELOIDOGYNE*)
IN GINGER. 1985-1988

P. Willers

Tissue culture technique were investigated as a method to obtain nematode free propagation material in limited quantities. For large scale disinfection of propagation material the dipping of rhizomes in aqueous solutions of the systemic nematocide, fenamiphos, was investigated. Methyl bromide as a pre-heated gas applied under gastight sheets was investigated as a pre-plant fumigant for nematode-, weed- and *Nigrospora* leafspot control.

Dazomet granules was evaluated for nematode and nutgrass control. Fenamiphos granules was evaluated for post-plant nematode control. Ginger agrotypes were evaluated for tolerance against root-knot nematode and leafspot.

In vitro culture of shoot tips from emerging buds on stored rhizomes, which were heavily infested with root-knot nematodes, resulted in plants completely free from nematodes. The dip treatment of ginger seed pieces in fenamiphos solutions rendered 70 % clean rhizomes, whereas the remaining 30 % contained acceptable levels of nematode infection. Methyl bromide used at rates of 50 g/m² and 75 g/m² gave sound control of root-knot nematode, nutgrass and *Nigrospora* leafspot. Yield increases of 53 % were achieved with both dosage rates. Dazomet can be used as a pre-plant treatment for nematode and nutgrass control at a rate of 50 g/m². Dazomet treated plots planted with nematode free rhizomes increased yield by 53 % when compared with control plots.

Fenamiphos used as a post-emergence nematocide provided good control of root-knot nematode. A single application of 10 g/m increased yield by 210 % whereas a double application using 10 g/m at planting and 3 months later increased yield by 260 % when compared to untreated control plots.

The ginger agrotypes available in South Africa displayed no differences regarding resistance against two root-knot nematode species but differences in tolerance to *Nigrospora* leafspot were prominent.

• Crop science

SS.2486/30/2/1:

TESTING OF OTHER SUBTROPICAL CROPS IN DIFFERENT LOCALITIES. 1975-1989
A.J. Joubert

The objective of this facet was to test the adaptability and production of different subtropical crops in various localities.

It was found that ginger is well adapted in the subtropical areas of South Africa. The estimated production on a commercial scale can be based on a plant material:yield ratio of 1:8 and it is recommended that 4-5 tons of ginger be planted per hectare. In a nursery, plant material can be increased at a ratio of 1:15. The best harvesting time for syrup ginger is at the end of February to the beginning of March when the fibre-free plant of the rhizome is between 50-60 %. Different ginger lines have a volatile oil content higher than the 2 % minimum standard. The following ginger lines are recommended for commercial production: G9 and C17 for general purpose marketing, G5/8 for syrup ginger and G1 for oil extraction.

Turmeric can be grown successfully in the subtropical areas of South Africa. A planting distance of 0,45 x 0,10 m is recommended. Tubers are the best planting material and September is the best planting time. An estimated yield of 40-50 tons per hectare was obtained in trial plots.

Pepper is a tropical vine which is adapted to the subtropical areas where bananas are grown successfully. A production of 1-2 kg processed dry pepper per plant mat can be obtained. The quality of locally produced pepper was rated as acceptable by spice traders.

This facet on the adaptability, production and quality analysis of ginger, turmeric and pepper is herewith terminated.

Nut crops

NUTS

• Pathology

SS.2491/19/2/1:

CHEMICAL CONTROL OF ANTHRACNOSE IN MACADAMIA NUTS. 1984-1987
N.M. Grech

This project was initiated in response to reports from farmers in the Levubu area who reported that their Nelmac 2 plantings were producing yields significantly below expectations. Attention was paid to raceme, nut and root diseases.

Colletotrichum gloeosporioides was the most important nut pathogen, whereas *Alternaria* and *Pestalotia* were the most prevalent flower pathogens. Economic chemical control of anthracnose was obtained with 3 mancozeb sprays commencing at flowering. Yield increases of 13 % were recorded. Nelmac 2 was found to be highly susceptible and cannot be recommended for future plantings on the basis of these findings.

During the course of the project, the Nelmac 2 trees were found to vary significantly in size and yield. It was also found that there is an annual nut drop approximately 1 month after nut-set. The cause of this nut drop has not been established, and could be physiological in origin. As the Nelmac 2 cultivar is highly susceptible to anthracnose, whereas the Hawaiian cultivars are not, and as 90 % of the nut crop is exported, it is suggested that preference should be given to the Hawaiian cultivars when new plantings are established. It is also recommended that improved, preferably clonal, rootstocks be developed.

• Pests

SS.2491/20/1/2:

BIOLOGICAL CONTROL OF STINK BUGS IN MACADAMIA NUT ORCHARDS. 1987-1989
T. Brink

Stink bug population surveys indicated that a complex of stink bugs is the cause of the damage on the kernels of macadamia nuts. The two-spotted stink bug (*Bathycoelia rodhaini*), an indigenous species, is the most important stink bug. At the moment the exotic green vegetable stink bug, *Nezara viridula* that was the initial culprit, is the fifth most important species.

Noticeable differences in the size of stink bug population occur between the Nelmac and Hawaiian cultivars resulting in greater damage in the Hawaiian cultivars (containing the larger stink bug population).

A parasitoid complex of the indigenous stink bugs were found during surveys. There are 4 wasp parasitoids of the eggs of the two-spotted stink bug and two parasitic flies which attack the adults. Two egg parasitoids of the coconut stink bug were also found.

A mass rearing technique for the green vegetable stink bug, *Nezara viridula* was developed where $\pm$ 10 000 stink bugs can be maintained in a rearing room. The stink bugs were used mainly for the mass rearing of the imported parasitoid, *Trissolcus basalus*.

A sequential sampling technique has been developed for the two-spotted stink bug. The technique enables the producer to determine, with the minimum number of samples, if the pest population needs to be controlled.

Susceptibility of the macadamia nut to stink bug feeding was determined throughout the season. Small fruit (2-8 weeks after fructification) were the most susceptible to damage. Damage on the macadamia nut kernel decreased as the fruit size increases. The decrease in damage is due to the increase in shell thickness. Shell thickness is the limiting factor for feeding on the nut kernel and not the hardness of the seed pod, as stink bug species with longer mouthparts are able to penetrate hard seed coats.

The successful rearing and release of the parasitoid, *Trichopoda pennipes* is a prerequisite for the biological control. An integrated pest management programme has to be evaluated, using pesticides which are the least harmful to the natural enemies of stink bugs.

PLANT PROTECTION RESEARCH

Entomology/Zoology

INSECTS

• *Integrated control*

PB.2511/23/1/6:

FEEDING BEHAVIOUR OF *HELIOTHIS ARMIGERA* LARVAE ON COTTON. 1983-1988
S.J. van der Walt

Five larval instars for *H. armigera* were found in both field and laboratory populations. The larvae were easily identified on the basis of their head-capsule widths and, further, are easily separated from the other bollworms which occur on cotton in South Africa.

The *H. armigera* larvae were found to occur in all compass directions and in all height zones of the plants. Although the larvae occurred mostly in the upper two-thirds of the plants, this was due to the distribution and availability of cotton buds, flowers and bolls (the "fruiting forms" used in the thesis) and not to a preference by the larvae. The larvae showed a clear preference for fruiting forms over leaves and there were indications of a preference for flowers over the other fruiting forms. This "preference" for flowers has little influence on the feeding habits of the larvae; feeding occurred on the most abundant fruiting forms and there are generally few flowers compared to buds and bolls in cotton fields. Therefore, the feeding habits of the larvae cannot be used to improve survey methods on which pest control strategies are based and whilst there is no need to examine cotton leaves, there is no alternative but to search all the fruiting forms on the plants. Improvements in the survey methods should be sought in developing sequential sampling procedures based on the collection of randomly selected fruiting forms rather than searching a fixed number of plants.

The study of feeding by the first two larval instars of *H. armigera* is incomplete in so far their selection of feeding sites, which does not correspond to the oviposition sites of the moths, was overlooked. A study of their dispersal remains an important research priority. Neither was their feeding on the growth tips of cotton plants examined. Detection of these small larvae is impractical in the field and moreover, their damage was insignificant in terms of quantity of food consumed and the numbers of fruiting forms that aborted owing to their feeding. In these respect the last three larval instars obviously caused most damage. Clearly, this is because the larger larvae are able to move greater distances and consume several of the small fruiting forms.

Measurements of the damage caused by *H. armigera* and other cotton pests are worthless without taking into account the ability of cotton plants to compensate for losses of fruiting forms. These plants characteristically produce more fruiting forms than can eventually ripen and abort the excess buds and bolls. Therefore, assessments of damage as a count of fruiting forms destroyed, provides little information on the actual yield losses and with our current spray programmes we may be protecting fruiting forms which will be lost for other reasons. A study of the pest status of *H. armigera* in relation to compensation by the plants should be undertaken.

The provisional investigation into the ability of cotton plants to compensate for damage by *H. armigera* showed that the plants did not compensate for damage done during the early stages of plant development and resulted in a yield loss. The damage done by bollworms late in the season was insignificant because most of the fruiting forms were unlikely to mature and contribute towards the harvest. This aspect deserves further attention.

STORED GRAIN

• *Pests*

PB.2518/20/1/1:

THE USE OF CONTACT INSECTICIDES FOR THE CONTROL OF INSECTS IN STORED GRAIN AND GRAIN PRODUCTS. 1962-1988
J.H. Viljoen

Use of contact insecticides on bag stacks against reinfestation

Every storage depot is considered a separate ecological unit so that a number of insecticides cannot be objectively evaluated at the same depot. To test the value of bag-stack sprays, therefore, 5 bag depots were

selected in the northern Transvaal and at each depot a different insect control programme was applied. All depots were fumigated. At two depots the stacks were sprayed with mercaptothion at four and six week intervals after fumigation. One stack was treated every six weeks with pirimiphos-methyl, a fourth stack was treated once with *Bacillus thuringiensis* and the fifth stack was not treated after fumigation and acted as the control. Every week, populations of *Ephestia cautella*, *Plodia interpunctella* and grain beetles were monitored. It was found that the pest populations at the five depots did not differ markedly from each other. These results were received with great scepticism and it was decided to repeat the experiment on a wider scale.

Thirty-six bag depots, grouped into fours, were treated after fumigation against insect reinfestation. There were 9 different post-fumigation treatments including four- and six-weekly sprays of mercaptothion, pirimiphos-methyl and untreated controls. The pest populations were monitored every week for 34 weeks and again no significant differences were found in the levels of reinfestation between the different depots. In fact, depots that received no post-fumigation treatment tended to have the lowest pest populations. These results confirmed the findings of the previous experiment that no post-fumigation treatment satisfactorily prevented the reinfestation of fumigated stacks. The inability of residual contact insecticides to protect fumigated bag stacks may be ascribed to a number of factors of which the most important is that the insecticides not only kill the pests, but also their natural enemies. Further, the insecticide does not prevent large numbers of eggs being laid in the grain where the young larvae escape the effect of the chemical sprays.

During these experiments it became clear that stacks were reinfested immediately after fumigation by insects in the immediate vicinity of the depot and no treatment succeeded in controlling these insects before they had laid their eggs in the grain. This observation led to the development of dichlorvos as a space spray and the possible control of grain pests using natural enemies.

Use of contact insecticides for the protection of bulk-stored grain

From 1960 to about 1974 contact insecticides were important to protect bulk grain from insect attack. In 1971, however, undesirable bromophos residues were found in export maize and later similar problems were encountered with pirimiphos-methyl in oilseed products. This resulted in a dramatic decline in the use of contact insecticides for pest control in bulk grain.

Initially, bromophos was developed to replace mercaptothion which had become progressively ineffective. Since 1979, three new chemicals were tested and registered - pirimiphos-methyl for summer grains and oilseeds, and deltamethrin and chlorpyrifos-methyl for summer and winter grains and oilseeds. Pirimiphos-methyl was not registered for use on winter grains because of its ineffectiveness against *Rhizopertha dominica*. Pirimiphos-methyl was also registered for use on hybrid maize seed. These three insecticides are still very effective but are seldom used because of fear for undesirable residues in export grain and this despite the fact that all three materials have reached Step 10 of the Codex procedure. Instead, the grain storage industry still relies on mercaptothion to control insects in grain that cannot be fumigated.

The future use of residual insecticides on bulk-stored grain in South Africa remains uncertain. Apart from the three chemicals already mentioned, six other products have been tested on a small scale, some with very good results. Other products are used overseas to protect grain so there is no shortage of potential products. In general they are a relatively cheap, convenient and effective means of protecting grain against insect pests but their practical use requires effective planning and management so that the requirements of overseas importers can be met. According to the shift in the grain production for export towards production for internal consumption, the value of residual grain protectants will increase.

PB.2518/20/1/2;

THE USE OF TOXIC AND INERT GASES FOR THE CONTROL OF STORAGE PESTS.
1962-1988

J.H. Viljoen

Control of moth pests in bag stacks

Since about 1960, moths *Ephestia cautella* and *Plodia interpunctella* have been the most important insect pests of grain in South African bag stacks. Spraying the surface of bag stacks after fumigation did not prevent these moths from laying their eggs in the grain. Furthermore, a thin layer of insecticide over the stacks could facilitate the selection of resistant pest genotypes which in turn could adversely affect the prolonged use of grain protectant pesticides. An extensive survey of 36 bag depots was undertaken over two consecutive years to monitor the efficacy of bag-stack treatments. It was found that natural enemies had the same suppressive effect on moth populations as insecticidal sprays alone, and that spray applications disrupted the effect of these biological agents.

To improve the moth control of bag stacks, two methods were evaluated to supplement those already in use. The first method was the daily application of dichlorvos as a space treatment to the store and stack while the stack was still being fumigated. This method killed all moths in and around the store before they could oviposit but it was necessary to apply the treatments daily for up to three weeks to control moths emerging from cocoons. This method proved expensive and difficult to implement because the insecticide had to be applied after work and over week-ends.

The second method was to encourage the reappearance of natural enemies of the two moth species such as the wasp parasite *Bracon hebetor*. Insecticide applications to several experimental bag stacks were suspended and only fumigation was used for pest control. As initial results were variable, the feral wasp populations were supplemented by the weekly release of laboratory-reared parasites. Weekly releases of *Bracon* sp. over 12 months in a depot at Coalbrook demonstrated that this wasp could successfully suppress populations of *E. cautella* and *P. interpunctella*. During the trial period the number of fumigations for general pest control were reduced from three to one and it was conservatively estimated that the use of *Bracon* sp. represented a saving of at least 70 % on the cost of conventional pest control. In the absence of the two moth species and less frequent fumigation, beetles such as *Sitophilus oryzae*, *S. zeamais* and rodents increased in abundance and it became necessary to investigate additional methods for their control. However, population increases of *Sitophilus* occur more uniformly and slower than those of the two grain moths. The possibility of using natural enemies against *Sitophilus* infestations and the minimum number, frequency and timing of *Bracon* sp. releases for the effective control of *E. cautella* and *P. interpunctella* are aspects that still require investigation.

The use of fumigants in grain silos

More than 90 % of all grain stored in South African silos relies almost exclusively on fumigants for protection against pest infestations. Presently only two fumigants are internationally accepted for the treatment of stored grain - phosphine and methyl bromide. The development of insect resistance against phosphine and the danger to human health of inorganic bromine residues in methyl bromide-treated grain are causing increasing worldwide concern. Further, there is little chance of developing suitable alternative fumigants. Consequently it is of the utmost importance for the food storage industry to apply the available chemicals in such a manner that will ensure their prolonged use. The only "new" fumigant currently under trial is carbon dioxide.

The gas retention and pressure tolerance of concrete silos

In the past, the local fumigation of grain silos was done without considering the ability of the silo to retain the fumigant. No objective measure of a silo's relative gas retention existed. Hermetically sealing concrete silos was not cost effective, so it became important to establish the degree of sealing needed for the effective use of fumigants such as phosphine in grain silos. Increasing the air pressure in a silo to 2 kPa and then recording the time taken for this pressure to fall to 1 kPa was used to calculate the half-life pressure retention capacity of a storage facility. In Australia a half-life of 12 min for an empty silo and 5 min for a full silo are considered an acceptable standard of pressure retention. In South Africa, the pressure retention of grain silos was found to be lower than the Australian standard, nevertheless a satisfactory concentration-time product (CT-product) could be achieved to make effective fumigation possible. Insects rapidly reinfested fumigated silos soon after treatment.

During pressure retention tests, air escaped from silos through cracks and construction joints in the floor. In a silo complex, adjoining silos were often linked by subterranean tunnels so that insects could move freely out of and between silos. This explained why fumigated silos were so rapidly reinfested after treatment.

The distribution of phosphine in a silo

The distribution of phosphine, grain temperature and humidity and insect infestations were monitored in a full grain silo. Phosphine-generating pellets were added to grain on the upper conveyor belt with an automatic pellet applicator. The pellets were distributed horizontally in one half of the grain because the applicator always placed the pellets in the same position on the conveyor belt and there was little mixing of the pellets and grain. Preliminary tests indicated that this problem could be overcome by applying the pellets to grain on the lower conveyor belt.

Pellet distribution influenced the horizontal distribution of the gas. In addition, there was a vertical concentration gradient of phosphine with the lowest concentrations at the bottom. In the central column of grain the CT-product in the lower third was sufficient to kill all insects only after 28 days of exposure. Furthermore, the position of the main silo exit above the grain allowed air to enter the silo and dilute the fumigant. The possibility of reinfestation from subterranean cracks and tunnels also hindered effective fumigation of the grain in this particular area.

Fumigation of maize in a partially filled silo

To determine the efficacy of phosphine fumigation while a silo was being filled, and to measure the effect of placing phosphine pellets on the lower rather than the upper conveyor belt, a silo with a capacity of more than 5000 m³ was filled with maize over 5 days until it was 65 % full. As the silo was being filled, phosphine-producing pellets were placed in the grain on the lower conveyor belt at a dosage rate 11 % lower than that recommended. Given a uniform gas distribution and adequate gas retention within a silo, it was found that grain could be effectively fumigated with as little as half the amount of pesticide presently recommended in South Africa. This could result in a 50 % saving on fumigation costs which in turn could enable the gas retention capacities of local silos to be improved. Renovation of silos to comply with the Australian gas retention standard will not prevent the reinfestation of fumigated grain unless attention is also given to insect-proofing silos. However, there are sealing methods that can improve a silo's gas retention and insect exclusion capabilities simultaneously. Attention should now be given to an assessment of the gas retention ability of South African silos and the cost-effectiveness of suitable sealing techniques.

The distribution of methyl bromide with a low-volume circulation system

As a grain fumigant, methyl bromide has certain advantages over phosphine. For example, the treatment time with methyl bromide is much shorter (24 h) than with phosphine (14 to 28 days). Methyl bromide was originally applied to grain through a silo's air circulation system. In South Africa, however, few silos have such facilities and consequently there is a need to develop a low-cost, low-volume gas circulation and application system for methyl bromide. Such a system was developed and installed in a standard 5000 m³ silo. The system produced a very satisfactory distribution of methyl bromide in the silo despite water condensing near the methyl bromide applicator and then freezing as liquid methyl bromide was released into the system. If this problem can be resolved, good results can be anticipated.

The use of methyl bromide and carbon dioxide mixtures

The concern of international health authorities about bromide residues in food has resulted in increasing resistance to the fumigation of grain with methyl bromide. To overcome this problem, the amount of methyl bromide required for acceptable pest control has been reduced to a low level by mixing the gas with carbon dioxide. In Australia, this method has been used successfully for the fumigation of grain in steel silos and it was evaluated in the more porous concrete silos in South Africa. Initial results were encouraging but there is a need to repeat the work and synchronise the circulation and application rates of the two gases.

The use of carbon dioxide in concrete silos

In Australia and the USA, carbon dioxide at 1 kg/t grain is used as a grain fumigant. The cost of this treatment in the Republic is similar to that with phosphine and it was decided to test carbon dioxide as a grain fumigant. In the first test, carbon dioxide was applied over 11 h at 1,28 kg/t grain. This produced an average concentration of 83,2 % CO₂ in the intergranular atmosphere. During the first 30 h after application, the loss of CO₂ was high (55 %), but this loss gradually declined until 16 days after treatment the silo atmosphere still contained 8 % CO₂.

The high initial loss of CO₂ was ascribed to adsorption by the grain and carbonisation of the concrete. During the first test, the carbon dioxide concentration did not conform to Australian or American recommendations, so it was decided to repeat the trial.

In the second trial, a CO₂ concentration curve similar to that obtained in Australia was achieved with the application of 2,67 kg CO₂/t grain. This was less CO₂/t grain than is used in the USA but the degree of pest control was similar to that obtained in Australian steel silos with 1 kg CO₂/t grain. The difference in the amount of CO₂ used reflects the importance of carbonisation as a factor in gas loss. Carbonisation may

adversely affect concrete and accelerate corrosion of steel structures. Present indications are that the internal surfaces of a silo will have to be treated before carbon dioxide can be used as a grain fumigant in addition to any treatment necessary to increase the gas retention of the structure.

FOREST AND TIMBER

PB.2519/20/1/2:

LABORATORY EVALUATION OF REGISTERED TIMBER PRESERVATIVES:
CO-OPERATIVE EXPERIMENT BY SAFRI AND PPRI. 1977-1987

J.K. Winstanley

The aim of this experiment was to ascertain the effectiveness over a number of years of the approved timber preservatives at present in use in South Africa and registered as such in terms of the Fertilisers, Farm Feeds, Agricultural and Stock Remedies Act No. 36 of 1947; also, later, to test potential newer candidate products.

Breeding and testing

Initial breeding cultures of various timber pest insects were established in the laboratories, but only four of these were finally selected for use:

Hylotrupes bajulus
Lyctus brunneus
Anobium punctatum
Cryptotermes brevis

The breeding methods are on file, together with the detailed biological testing methods, and further literature references to all of these are available.

Lindane Smoke Deposits

Pyrotechnic formulations incorporating Lindane were prepared in 1977-1978. Pine blocks were exposed to these treatments and *Hylotrupes* larvae were used for the biological tests on the timber. Full details of the work and the results were reported in Rosebank annual reports 1980-1985. This project provided basic information, but the method and treatment cannot be recommended for practical control of woodboring pests.

Preservative-treated wood blocks

In the first series of wood blocks tested, nine different wood preservatives at five concentrations each were screened, and the detailed results were given in the annual reports for 1980-1984. In general, all treatments with Lindane or TBTO/Lindane were shown to give best insecticidal effects, while Bardac 20 proved weak.

In the second series, both Sasol and Iscor creosotes, as wood preservatives, proved to be so toxic to the insects that over the test period of nine years, no comparative results could be obtained. Both creosotes would undoubtedly prove useful in the field.

In the third series, eighteen wood preservative treatments, many of them at five different concentrations, were tested, and the detailed results were given in the annual reports for 1983-1987. The AAC treatments and possibly Boliden P50 were weaker than the remainder. In the normal way with wood preservative testing, the procedure would have been reported each year for a further eleven years to show up the differences more clearly.

A fourth series comprised DNBP-treated wood blocks, and the results were presented in 1987. These treatments, however, were later withdrawn by the authorities because of health hazards.

A fifth series compared Rodewod formulations against CCA as the standard, and the results (in 1988) showed that these treatments were very promising.

Termite repellents

Two batches of potential termite repellents were received for testing, and the detailed results were reported in 1986 and 1987.

Registration applications for wood preservatives under Act No. 36 of 1947 have been influenced directly by the results of this experiment even though the initial aim of the project does not allow for the independent publication of the test results.

PB.2519 20 1 6:

THE SEASONAL ABUNDANCE OF PINE APHIDS IN THE WESTERN CAPE. 1987-1988
J.K. Winstanley

The Western Cape Forestry Region differs from forestry regions in the rest of South Africa on two accounts. Firstly, it has a winter rainfall and secondly it is characterised by very poor soils. Tree growth in the western Cape, therefore, is poor and the trees are generally very prone to pests and diseases. Since 1974, three new exotic pine tree aphids have appeared in South Africa. These are the black pine aphid, *Cinara cronartii*, the pine woolly aphid, *Pineus pini* and the pine needle aphid, *Eulachnus rileyi*.

These aphids have caused great concern in the Transvaal, Natal and eastern and southern Cape, but they are also found in the western Cape. In the western Cape little concern has been shown over the presence of these aphids in local plantations so this study was undertaken at the Lebanon State Forest near Grabouw to monitor the seasonal abundance of the aphids and determine their potential importance.

Of the three aphid species monitored at Lebanon State Forest during 1985-1988, none inflicted serious damage to their hosts. The pine woolly aphid is considered the species most likely to sporadically caused damage, especially to *P. pinaster*. The pine needle aphid, despite being the most abundant species during the study period, did not cause visible damage to the needles of its hosts. The black pine aphid is unlikely to become a problem in the western Cape mainly because of the adverse climate and the unsuitability of the pine species grown in the area.

Plant pathology/Microbiology

FUNGI

- Taxonomy

PB.2521/01/1/5:

THE SPECIES OF THE GENUS *PHYTOPHTHORA* IN SOUTH AFRICA. 1988-1990
A.H. Thompson

The work on *Phytophthora* root rot of cabbage is now complete and is at present being published. The work on *Phytophthora* root rot of anthurium is still being revised. The work on *Phytophthora drechsleri* and *P. megasperma* from lucerne is almost complete. All gels have been run and are awaiting scanning, measurement and computer analysis. Thereafter, the work will be published. Preliminary work on using protein patterns in the taxonomy of *Termitomyces* and *Rhizoctonia* seems promising and should be further pursued.

- Pathology

PB.2521/19/2/5:

THE FUNGUS *PHYTOPHTHORA CINNAMOMI* IN THE WESTERN CAPE: FACTORS AFFECTING SURVIVAL, SPORULATION AND INFECTION BY THE FUNGUS *PHYTOPHTHORA CINNAMOMI*. 1985-1988
S.L. von Broembsen

A two-year study of factors affecting sporulation and release of propagules of *Phytophthora cinnamomi* into a stream draining a closed fynbos catchment was carried out. Meteorological data was collected continuously and sampling was carried out fortnightly throughout the study. The catchment was purposely burnt at the end of the first year of the study so that the effects of this management practice on various aspects of the ecosystem could be studied.

A major objective of the study was to compare sporulation and appearance of the fungus in the stream during the first year with that of the second year. During the second year of the study, the levels of *Phytophthora* were higher and moderate to high levels occurred over a longer period of time than in the first year. This was probably due to the increased soil temperatures which occurred after the burn removed most of the plant cover.

Low levels of propagules (0-20/ℓ) were found in winter to mid-spring (May-September), whereas 50-350 propagules/ℓ were recovered during summer and autumn (November-April). Thus, the highest levels of *Phytophthora* spp. appear in headwaters of rivers during the period when these rivers are used for irrigation.

PB.2521/19/2/6:

THE FUNGUS *PHYTOPHTHORA CINNAMOMI* IN THE WESTERN CAPE: ASSOCIATED OF THE FUNGUS *PHYTOPHTHORA CINNAMOMI* WITH DECLINE AND MORTALITY OF INDIGENOUS SHRUBS. 1985-1988

S.L. von Broembsen

Tree health was monitored in healthy and diseased forests at Witelsbos, Loerie and Biervlei in the southern and south-eastern Cape Province to study the spread of *Phytophthora* root rot. Tree health ratings of all trees previously rated in July 1986 at the three above locations were taken again in July 1987 and July 1988. Tree health declined at all diseased sites but not at the control sites during the first two years. Declining trees tended to occur in groups.

A trial designed to study the pathogenicity of *P. cinnamomi* to mature trees under field conditions was laid out in an apparently healthy area of indigenous forest at Witelsbos. Roots of stinkwoods were inoculated with *P. cinnamomi* in December 1987. Root lesion development of all trees inoculated with *P. cinnamomi* was measured in June 1988. Lesions of roots inoculated with either of two isolates of *P. cinnamomi* were significantly longer than for the controls.

Indigenous trees in three indigenous forests in the north-eastern Transvaal were sampled for *P. cinnamomi* in January 1988. *P. cinnamomi* was recovered from more than half of the root and soil samples which were collected. *P. cinnamomi* occurred in Entabeni, Woodbush and de Hoek State Forests.

Hosts recorded were *Ocotea kenyaensis*, *Cryptocarya liebertiana*, *Syzygium gerrardii*, and *Nuxia coangesta*. Only *C. liebertiana* had previously been found as a host. Most of the trees sampled showed no apparent disease symptoms.

PB.2521/19/2/7:

THE FUNGUS *PHYTOPHTHORA CINNAMOMI* IN THE WESTERN CAPE: CONTROL OF ROOT ROT OF PINCUSHIONS CAUSED BY *P. CINNAMOMI*. 1985-1988

S.L. von Broembsen

Phytophthora root rot is a limiting factor in the production of cut flower pincushions worldwide, but especially in South Africa. Investigations were initiated to identify root rot resistance within *Leucospermum* that might be utilised for the development of resistant cultivars or rootstocks.

Three different methods were used to assess the resistance of *Leucospermum* hybrids and species selections. Firstly, shoot cuttings were wound-inoculated with *P. cinnamomi* mycelium under controlled laboratory conditions. Lengths of lesions which developed from the inoculations were used to estimate relative resistance. This detached shoot assay proved too unreliable to be used for assessment, but it demonstrated that all lines were susceptible to the disease.

Secondly, one-year-old rooted cuttings were inoculated by applying zoospores of *Phytophthora cinnamomi* to the soil mix of individual pots in a trial conducted in a shade house. All of the lines tested were found to be susceptible to infection. However, some lines were tolerant to infection and disease development.

Thirdly, field evaluations of resistance were carried out at a site with high natural inoculum levels and soil factors favouring disease for three years. Good levels of tolerance were observed for several hybrids and species selections. Useful differences in tolerance were also recorded between breeding lines within species. The most tolerant lines are being further evaluated.

PB.2521 19/4/1:

THE FUNGUS *BOTRYOSPHAERIA DOTHIDEA* IN THE CAPE PROVINCE: HOST RANGE, DISTRIBUTION AND PATHOGENICITY OF THE FUNGUS *BOTRYOSPHAERIA DOTHIDEA*. 1985-1988

J.A. van der Merwe

The host range and distribution of *Botryosphaeria dothidea* was further investigated in the south-western Cape Province, with emphasis on proteaceous hosts of that region. Several methods of inoculating woody stems with *B. dothidea* were compared for effectiveness and feasibility. The pathogenicity of *B. dothidea* to *Protea* species and cultivars was tested under controlled and field conditions. Pathogenicity of different *B. dothidea* isolates to proteaceous hosts was also evaluated in both pot and field trials on plants of different ages.

B. dothidea was recorded on 86 hosts from 23 localities. Forcing toothpicks containing mycelium of the fungus into stems proved to be the most reliable method of inoculation of the three methods tested. *Protea grandiceps* and *P. cynaroides* were shown to be the most susceptible of the commercially important species. Susceptibility did not vary with age of plants and results from pot inoculations were consistent with those obtained in the field. Isolates of *B. dothidea* differed greatly in pathogenicity but the relative pathogenicity amongst isolates held for all the proteaceous hosts. Pot inoculation tests can thus be used to screen large amounts of material effectively, provided the pathogenicity of the isolates utilised is controlled.

PB.2521/19/4/2:

THE FUNGUS *BOTRYOSPHAERIA DOTHIDEA* IN THE CAPE PROVINCE: FACTORS AFFECTING SPORULATION, INFECTION AND DISEASE DEVELOPMENT BY THE FUNGUS *BOTRYOSPHAERIA DOTHIDEA*. 1985-1988

J.A. van der Merwe

The seasonal pattern of sporulation of *B. dothidea* was determined by trapping and counting spores in a naturally infected commercial planting of *P. grandiceps* for one year. Climatological data such as temperature, rainfall and relative humidity were recorded throughout the trial. The effect of temperature of mycelial growth, conidial production and conidial germination was investigated under controlled conditions in the laboratory. The relationship between wounding and infection was also examined under controlled conditions.

Sporulation occurred from spring to late summer whenever there was rainfall. However, sporulation was negligible during winter months despite abundant rain. Analysis of climatological data showed that the most important factors affecting sporulation were average daily temperatures above 20 °C and rainfall. Mycelial growth was maximum at 25 °C, but was good over a range of 15-30 °C. Conidial production and germination were highest at 20-25 °C. Infection studies showed that wounding was necessary for infection and that infection was greatest at 25-30 °C.

PB.2521/19/4/3:

THE FUNGUS *BOTRYOSPHAERIA DOTHIDEA* IN THE CAPE PROVINCE: CONTROL OF CANKER AND DIE-BACK OF CUT-FLOWER PROTEAS CAUSED BY THE FUNGUS *B. DOTHIDEA*. 1985-1988

J.A. van der Merwe

The effects of three fungicides and six wound sealants containing fungicides on mycelial growth, conidial production and conidial germination of *B. dothidea* were examined in the laboratory. The fungicide and the wound sealant which inhibited these processes best were then evaluated in the field for their effectiveness in preventing infection of pruning wounds. The ability of insecticide application to enhance control of *Botryosphaeria* canker was also tested under field conditions.

Benomyl at 2000 ppm completely inhibited mycelial growth, conidial production, and conidial germination under controlled conditions. The best wound sealant against *B. dothidea* was Hostaseal. Under field conditions, benomyl applied as a spray following pruning gave better control of infection of pruning wounds than Hostaseal. When the pesticides chlorpyrifos and dimethoate were included as monthly sprays in combination with benomyl and captab, control of *Botryosphaeria* canker was better than with the two fungicides alone. This suggests that insect wounds also serve as sites for infection. However, the single most effective measure against *Botryosphaeria* canker and die-back was the regular removal and destruction of all dead and dying plant parts from the planting.

PB.2521/19/5/1:

THE FUNGUS *DRECHSLERA DEMATIOIDEA* IN THE CAPE PROVINCE: HOST RANGE, DISTRIBUTION AND PATHOGENICITY OF THE FUNGUS *D. DEMATIOIDEA*. 1985-1988

S.L. von Broembsen

Drechslera dematioidea was found to be associated with a blight disease of pincushions (*Leucospermum* spp.). The host range and distribution of *Drechslera dematioidea* were determined with respect to *Leucospermum* spp. The pathogenicity of *D. dematioidea* to pincushions was tested under controlled and field conditions. The extent and severity of the blight disease were assessed and the susceptibility of pincushion cultivars was evaluated.

Pincushion blight was shown to be caused by *Drechslera dematioidea* and was described for the first time. *Drechslera* blight caused by *D. dematioidea* was found to occur in all the major pincushion growing areas of the Cape Province and the Transvaal. The fungus was shown to be seed-borne and to be spread

with vegetative cuttings. The disease was also recorded on pincushions in their native habitat. *D. dematioidea* was found on ten species of *Leucospermum* and forty eight pincushion selections, cultivars and hybrids. *Leucospermum cordifolium* and cultivars derived from *L. cordifolium* were the most severely affected.

A method of evaluating the field susceptibility of pincushion cultivars to Drechslera blight was developed and utilised to evaluate eleven cultivars. A wide range of susceptibility was recorded amongst the eleven cultivars evaluated in the field. Four cultivars were moderately resistant and two cultivars were highly resistant to Drechslera blight. A detached shoot assay for evaluating relative susceptibility of pincushion cultivars to Drechslera blight was developed, tested and found useful for this purpose.

This quick, effective and relatively inexpensive assay can now be used for large scale screening of pincushion breeding lines and cultivars for resistance to Drechslera blight.

BACTERIA

• Nitrogen fixation

PB.2522/09/1/14:

BACTERIA: PRODUCTION OF INDOLE ACETIC ACID BY STRAINS AND MUTANTS OF RHIZOBIA: POSSIBLE EFFECTS OF THE HOST PLANT. 1985-1988

I.J. Law

The indigenous N_2 fixing *Bradyrhizobium* strains 45E and 45G inhibited tap root growth when broth cultures were inoculated directly onto cowpea seedlings. This phenomenon was not observed with other isolates nor with two culture collection strains XS21 and XFD2. Washed cell suspensions of strains 45E and 45G did not inhibit tap root growth which appeared to result from the synthesis of indole acetic acid (IAA) by the two strains in culture. The inhibitory effect of cultures on tap root growth did not affect subsequent lateral root formation and nodulation by strains 45E and 45G, nor was growth stimulation and shoot dry mass reduced. Strains 45E and 45G were, however, less effective than strains XS21 and XFD2.

Strains 45E and 45G also had an inhibitory effect on the root growth of cowpea seedlings when cells or broth cultures were incorporated in agar in contact with the roots. In contrast strain XS21, but not strain XFD2, stimulated cowpea root growth under these conditions. Some stimulation of wheat root growth by strain XS21 was similarly observed but the *Bradyrhizobium* strains did not influence wheat growth in subsequent greenhouse tests.

Production of IAA by the four test strains was dependent on medium composition and all strains were capable of synthesising this phytohormone although strains 45E and 45G were more consistent in this regard. Nine methyl-tryptophane-resistant mutants of strain 45GCmSp were isolated of which five produced more IAA than the parent strain in a defined medium supplemented with tryptophan. Two of these mutants incited significantly less nodule material than strain 45GCmSp but all the mutants were as effective as the parent strain in their ability to stimulate cowpea growth.

The above tests indicated that phytohormone production by the strains and mutants of *Bradyrhizobium* was likely to influence plant growth either in the greenhouse or in the field.

PB.2522/09/1/16:

BACTERIA: EFFECT OF FOREIGN PLASMIDS ON THE SYMBIOTIC PROPERTIES OF RHIZOBIA MELILOTI .1985-1988

I.J. Law

Two plasmids, pAgK84 from *Agrobacterium tumefaciens* carrying genes for the production of the bacteriocin agrocin 84, and RP4-4 from *Escherichia coli* carrying Ampicillin and Tetracycline resistance determinants, were inserted either separately or together into a strain of *Rhizobium meliloti*.

The plasmid-containing *R. meliloti* isolates were found to be significantly less effective ($P = 0.01$) than the parent strain in their ability to stimulate growth of *Medicago tornato*. The isolate containing only pAgK84 was significantly less effective than isolates containing either RP4-4 alone or both RP4-4 and pAgK84.

There was no evidence of plasmid loss by either of the isolates containing single plasmids after their reisolation from nodules. However, up to 80% of the nodules from plants inoculated with the isolate containing two plasmids yielded rhizobia that had lost pAgK84. The plasmid-containing strains were marginally less efficient than the parental strain in their ability to nodulate seedlings when inoculated singly, and were inferior to the parent strain in their ability to compete for nodulation especially when applied at a low inoculum concentration.

The above results suggest that foreign plasmids, have the potential to impair the *Rhizobium*-legume symbiosis, a factor that requires consideration when using these as a vehicle for the introduction of foreign genes into *Rhizobium*.

FOREST AND TIMBER

• Pathology

PB.2525/19/2/1:

PATHOGENICITY, HOST RANGE AND SPREAD OF *VERTICICLADIELLA* SPP. CAUSING
ROOT DISEASES OF PINES. 1986-1988

M.J. Wingfield

The taxonomy of the genus *Verticicladiella* has been in a confused state for many years. This had led to a re-evaluation of the genus and ultimately, on the basis of conidiogenous cells to reducing *Verticicladiella* to synonym with *Leptographium*. In further developing a scheme for identification of pathogenic *Leptographium* spp. in South Africa, it has been necessary to consider other members of the *Leptographium* complex such as *Phialocephala*. Thus various *Phialocephala* spp. were transferred to the genus *Sporendocladia*.

Leptographium spp. are fungal pathogens commonly isolated from conifers infested with insects. They are carried by the insects and contribute to the establishment of vectors in trees. Numerous *Leptographium* spp. have been associated with root diseases of conifers. The best known of these is *Leptographium wageneri* that causes black stain root disease in the Western United States. *Leptographium procerum* is associated with white pine root decline and *L. serpens* has been associated with pine root disease in Italy and South Africa. A review on these fungi and their importance has been outlined in a recent publication providing an international perspective to the subject.

Leptographium procerum has been found in South Africa for the first time during the course of this study. This fungus is considered to be an important pathogen of conifers in North America and Europe. However, the results of preliminary trial comparing the pathogenicity of this fungus with that of other pathogenic *Leptographium* spp. indicate that it is a weak pathogen. However, its effect in combination with other fungi carried by the same insects is as yet unknown.

PB.2525/19/3/1:

HOST RANGE AND SPREAD OF *SPHAEROPSIS SAPINEA* ON PINES IN SOUTH AFRICA.
1986-1988

W.J. Swart

Many reports associate the damage caused by the fungus *S. sapinea* with tree vigour and environmental influences on the tree rather than with the occurrence of the pathogen itself. Our research has, therefore, concentrated on understanding the life cycle of *S. sapinea* with respect to the virulence of different *S. sapinea* isolates and the susceptibility of different pine species to infection.

In the north central United States, cultural and morphological differences among isolates of *S. sapinea* have recently been demonstrated for the first time. Two distinct types were identified which are indicative of genetic divergence in *S. sapinea*. It is speculated that type A isolates were considerably more pathogenic than type B isolates which have more of an opportunistic nature. This work represents a very important breakthrough in understanding the biology of *S. sapinea*. As a result of this work, we screened various *S. sapinea* isolates to determine the degree of genetic divergence. Distinct differences on morphology and pathogenicity have been demonstrated for some local isolates. Techniques used included in vitro growth studies, greenhouse and field inoculations and scanning and transmission electron microscopy.

Investigations into the relative susceptibility of *P. radiata*, *P. pinaster*, *P. elliottii*, *P. kesiya* and *P. taeda* using different isolates of *S. sapinea* have been concluded. The relative susceptibilities of these pines to *S. sapinea* in greenhouse and field inoculations compared favourably with field observations by foresters over a number of years. Our results showed that *P. radiata* and *P. pinaster* are generally more susceptible to *S. sapinea* than *P. elliottii*, *P. patula* and *P. taeda*. Although our growth chamber inoculations did not indicate significant differences in susceptibility between *P. radiata* and *P. pinaster*, results of our field inoculations indicated that *P. radiata* was significantly more susceptible. *P. kesiya* is reported to be almost completely free from diseases and pests and because of its excellent timber has been commended for use on an increased scale in Southern Africa. The results of our study, however, show that *P. kesiya* is as susceptible to *S. sapinea* under growth chamber conditions as *P. radiata* and *P. pinaster*.

One objective of this study was to determine what time of the year conidia are dispersed and whether this differs in the three different rainfall regions of the country. Conidia of *S. sapinea* were trapped over a two-year period by exposing VaselineR coated microscope slides in three plantations situated in the winter rainfall region (Jonkershoek State Forest, Stellenbosch, south-western Cape Province), whole-year rainfall region (Saasveld Forest Research Centre, George, southern Cape Province) and summer rainfall region (Isidenge State Forest, Stutterheim, eastern Cape Province).

In all three regions, more *S. sapinea* spores were collected during weeks in which rain occurred than during dry weeks. At Jonkershoek, maximum annual rainfall occurred during July when temperatures were at their lowest. It preceded maximum spore dispersal by 16 weeks. At Saasveld and Isidenge, maximum annual rainfall occurred during November and preceded maximum spore dispersal by 8 and 12 weeks, respectively.

Maximum conidial dispersal occurred in spring (October) in the winter rainfall region, in early summer (December) in the constant rainfall region and in late summer (February) in the summer rainfall region.

Maximum dispersal of *S. sapinea* conidia occurred during wet weather, but there was also a seasonal periodicity in dispersal which was not related to maximum rainfall periods. The seasonal periodicity seems to be related to prevailing temperature conditions after the periods of maximum rainfall. At Jonkershoek, relatively low temperatures prevail during and for some time after the rainy period. Spore dispersal is, therefore, delayed longer than at Saasveld or Isidenge where maximum rainfall occurs during the warmer spring and early summer months. Natural infection of pines by *P. sapinea* is highest during shoot elongation when the tissue is most susceptible to infection. Infection will, therefore, be at a maximum during late spring and early summer.

In South Africa, it is the practice to prune commercially grown pine trees during dry weather. In the constant and summer rainfall regions, pruning takes place during winter, and in the winter rainfall region pruning is done during summer. Results of this study suggest that winter pruning is justified in all three climatic regions despite the occurrence of rain in the winter rainfall region.

A further objective of this study was to establish where and in what form the fungus survives periods which are unfavourable to its propagation on living plant material. Its ability to survive on dead host tissue will determine the most of inoculum which is available for infection in the rainy season when spores are dispersed. To study survival one needs a selective medium on which one can isolate the fungus without interference from common saprophytes. Such a medium was successfully developed in our laboratory.

Insects can play an important role in the development and transmission of tree diseases. Many of these diseases are caused by *Ceratocystis* spp. that are commonly carried by bark beetles. Insects can be involved in tree diseases in the following three ways:

1. They can carry primary pathogens and transmit these to healthy trees during maturation feeding.
2. They carry a range of pathogenic *Ceratocystis* spp. which can contribute to the death of stressed trees infested by less aggressive insects.
3. Their presence in dying trees can serve as a useful indicator of root diseases.

Ceratocystis spp. are virtually unknown in South Africa and the first was reported associated with the bark beetle *Orthotomicus erosus* in 1980. Subsequent studies have shown that the three pine infesting bark beetles occurring in the country carry a range of *Ceratocystis* spp. including numerous species that have yet to be described. However, each of the three insects primarily carries a single fungus. *Hylastes angustatus* primarily carries *Leptographium serpens* whereas *Hylurgus ligniperda* primarily carries an unidentified *Ceratocystis* sp. and *O. erosus* carries *Ceratocystis ips*, *L. serpens* and *C. ips* have been shown to be strongly pathogenic. The pathogenicity of other fungi associated with these insects is unknown.

Because *Ceratocystis* spp. are important pathogens and virtually unknown in South Africa, and attempt has been made to find these fungi on insects associated with native plant and to compare them with those associated with introduced insects. This has led to the discovery of a new species of *Ceratocystiops* on *Protea*

repens. It has an anamorph of unknown generic affinity and this has been assigned to a new genus *Knoxdaviesia*. The discovery of this new fungus is likely to revolutionise the thinking on this group of fungi which are typically associated with insects on trees in the northern hemisphere.

PB.2525 19 10 1:

ROUTINE DIAGNOSIS OF FOREST TREE DISEASES IN THE TRANSVAAL. 1985-1988
J.E. Lundquist

The occurrence and distribution of different fungi associated with pines and eucalyptus in South Africa has always been difficult to determine because no systematic countrywide survey has ever been done. Despite this, several records of the occurrence of fungi have appeared in published papers. Many more are available in unpublished correspondence and reports. The aim of this work was to prepare lists of these records, which could be used as a reference for those interested in examining in detail the occurrence in time and distribution in space of different forest fungi and fungal tree diseases in South Africa. Records from Transkei and Swaziland were also included.

The lists included over 1 000 reports for pines and over 400 reports for eucalyptus. They encompassed records of the National Collection of Fungi, items in the Forestry Branch's Annual Reports beginning 1885, published papers and unpublished survey data of the Forest Pathology Unit.

The earliest report of a fungus associated with pines was recorded in 1899, when *Hysterium pinastri* was discovered causing top die-back of *Pinus radiata* near Cape Town. Since then 189 fungi have been associated with 34 species and varieties of pine. Among the most commonly reported fungi have been *Sphaeropsis sapinea*, the cause of Diplodia die-back, *Armillaria* sp., the cause of Armillaria root rot and *Rhizina* sp., the cause of *Rhizina* root rot disease. The earliest report for eucalyptus was recorded in 1910, when *Coltricia* sp. was found with an unidentified eucalyptus species at Wellington in the Cape Province. Since then, 148 different species of fungi have been found with 39 species and varieties of eucalyptus.

These lists provide a framework for information on forest fungi, much of which would probably otherwise remain hidden and unused in archives, annual reports and accession lists. Such information in a suitably structured format could be used to determine the distribution and relative significance of different fungi and fungal diseases, as an aid to field diagnosis of diseases and as a basis from which to search for and report the occurrence of fungi in our commercial forests more systematically.

PB.2525/19/10/5:

ROUTINE DIAGNOSIS OF FOREST TREE DISEASES IN THE CAPE PROVINCE AND
NATAL. 1986-1988
M.J. Wingfield

The aim of this project has been to provide an advisory service to the forestry industry of South Africa. This has been achieved by writing newsletter articles, pamphlets, book chapters and presenting lectures. In addition, surveys have been conducted on a yearly basis and samples of diseased trees received and examined.

As a part of the educational purpose of this project, a general publication has been written on forest tree diseases in South Africa. This publication outlines the biology and occurrence of the most important diseases and where possible suggests control measures. It forms part of a forestry handbook which is widely used by the South African forestry community. Furthermore, a short article explaining the purpose of the forest pathology programme in South Africa has been published.

Exploratory research on newly recognised diseases has been conducted to determine the cause and extent of these diseases. New diseases identified, include cypress canker caused by *Seiridium cardinale* and *S. unicornae* and brown needle disease of *Pinus radiata* caused by *Mycosphaerella gibsonii*. Both diseases have the potential to be extremely important in South Africa. However, *Cupressus* spp. are not widely planted except as ornamental plants and thus, cypress canker is unlikely to be of great significance.

In forestry, diseases tend to be of a complex nature and usually involve numerous components. Two disease situations examined in detail exemplify this fact. Firstly death of *Widdringtonia cedarbergensis* appears to be associated with fire damage which is followed by infection by various fungi and infestation by insects. Similarly when pines are mildly damaged by fire the heat of the fire can stimulate the root pathogen *Rhizina undulata* to become active. Trees further stressed by this pathogen are attractive to bark beetles which carry pathogenic fungi.

• Pathology

PB.2526/19/1/12:

PASTURE CROPS: YIELD LOSSES BY AND RESISTANCE TO COLLETOTRICHUM CROWN ROT OF LUCERNE CULTIVARS IN THE CAPE PROVINCE. 1985-1988

Susan H. Koch

Colletotrichum crown rot (CCR) of lucerne (*Medicago sativa*) was recently recorded in South Africa for the first time since 1915. The disease resulted in a severe stand depletion of lucerne fields planted with the newly imported lucerne cultivar Cuf 101. CCR was subsequently recorded in commercial lucerne fields and cultivar evaluation trials, mostly under irrigation throughout the Cape Province.

A partially selective medium was developed which consisted of 10 mg ai tridemorph and 5 mg rose bengal incorporated in 1 dm³ malt extract agar, to aid the isolation of *Colletotrichum trifolii* and other *Colletotrichum* spp. involved in CCR of lucerne. The following five *Colletotrichum* species were identified from lucerne largely on the basis of their conidial shape: *C. coccodes*, *C. dematium*, *C. destructivum*, *C. trifolii* and *C. truncatum*. *C. coccodes* and *C. truncatum* were recorded for the first time from lucerne in South Africa. *C. dematium*, *C. destructivum*, *C. trifolii* and *C. truncatum* were shown to be pathogenic to lucerne, and differences in disease intensity on this host were observed. *C. trifolii* was the most pathogenic species.

The disease reaction of lucerne cultivars and accessions to *C. trifolii* infection was evaluated under glasshouse, shadehouse and field conditions. Seedlings died within 14 days. Results obtained in the shadehouse and field correlated well.

Accessions differed significantly in their disease reaction. Cuf 101 was one of the most susceptible cultivars. S.A. Standard and Trifecta were two of the most resistant cultivars to CCR. The absence or low occurrence of CCR from South Africa for many years could be due to the previously exclusive cultivation of the resistant S.A. Standard. Among the cultivars screened are some which were both high-yielding and resistant to CCR and the more common anthracnose symptoms caused by *C. trifolii*. These should be screened for general fitness under South African conditions and for resistance to other local pathogens. They might also be considered for inclusion in future local lucerne breeding programmes.

Weed research

WEEDS

• Physiology

PB.2551/03/2/1:

UPTAKE AND TRANSLOCATION OF HERBICIDES IN BRAMBLE (*RUBUS* SP.). 1981-1987
D.J. Erasmus

At the commencement of the project, chemical control measures for problem *Rubus* sp. (mainly *Rubus cuneifolius* Pursh. commonly referred to as American bramble) were unsatisfactory and, therefore, it was decided that various aspects including uptake, translocation, efficacy of herbicides, time of application and effect of site on efficacy should be investigated.

Although this species is perennial, the top growth of American bramble is biennial; the first year canes, known as primocanes, are vegetative. In the second year, the canes bear flowers and fruit and are then known as floricanes. On completion of fruiting the floricanes senesce and die. The continuous production and death of the canes result in the development of a woody root crown at or below ground level. The plant also has an extensive root system from which numerous suckers are produced.

For the uptake and translocation studies, the radio-active tracer derived from ¹⁴C sucrose was used. This was based on the assumption that most of the foliar-applied systemic herbicides are transported in the assimilate translocation stream of plants.

In field experiments, the seasonal translocation of assimilates was investigated to incorporate the various growth stages of the plant. It was found that in primocane plants, acropetal translocation to the apical region of the cane occurred during spring and early to mid-summer. Maximal basipetal translocation to the roots occurred in late summer. In the floricanes (these plants also had primocanes), assimilates were transported from the floricanes to the primocanes during summer. On completion of fruiting and at a

stage where the florican senescence had commenced, basipetal translocation to the roots was maximal. The root crown did not form a barrier to the translocation stream but according to the literature on this genus, this may occur with the movement of herbicides.

Effect of leaf age and position on the plants was investigated in greenhouse grown plants. Although radio-active tracer was taken up by new leaves (not fully expanded), no export of assimilates occurred. In fully expanded senescent leaves, absorption and export of the tracer took place. With respect to leaf position on the plant, leaves near the apex translocated assimilates to the apical sink region; those midway down the cane exported assimilates both acropetally and basipetally whereas leaves near the base of canes transported assimilates to the roots. In plants where the apical sink region of the canes was removed, greater basipetal movement occurred.

Herbicide field trials were conducted on American bramble to:

- compare the efficacy of the two registered foliar applied herbicides;
- compare the efficacy of the herbicides applied to American bramble in different bioclimatic regions; and to
- compare efficacy of the herbicides applied in early or late summer.

The trial plots were situated in dense infestations of American bramble in grassland at four localities in Natal. Both the registered herbicides, glyphosate (trade name Roundup) and triclopyr (trade name Garlon 4), were applied by knapsack sprayer at the recommended dosage.

The chemical control results obtained, showed the following:

- efficacy varied from site to site;
- triclopyr was generally more effective than glyphosate;
- late summer application generally resulted in greater mortality than early summer application.

These results are supportive of those obtained in the radio-active tracer studies where it was found that basipetal translocation of assimilates was greatest in late summer/autumn. Neither of the treatments resulted in 100 % mortality of American bramble. It is therefore essential that follow-up spot spraying be implemented.

It is pertinent to note that there were marked differences in the grass cover obtained in the trials. With triclopyr 95 %-99 % grass canopy cover was recorded in all plots with the exception of the late summer trial at one of the sites where 46 % cover was recorded. With glyphosate, less than 50 % grass canopy cover was recorded in all the plots. This is consistent with the characteristics of the two herbicides. Triclopyr is a selective broadleaved herbicide and glyphosate is non-selective. Therefore, any grass present at the time of herbicide application was killed by glyphosate but not triclopyr and hence the higher percentage cover.

The results obtained showed that for the control of American bramble in the veld situation, foliar application of triclopyr in late summer is the most suitable treatment currently available. In timber plantations where grass cover is of little importance, glyphosate can also be used albeit less effective than triclopyr.

PESTICIDES

• *Physiology*

PB.2552/03/1/1:

INTERACTION BETWEEN PESTICIDES: INTERACTION BETWEEN DIMETHOATE AND BROMACIL IN CITRUS ORCHARDS. 1980-1986

E.R.I.C. Sandmann

Research into the nature of the phytotoxic interaction of soil-applied bromacil and dimethoate on citrus (*Citrus* spp.) trees was undertaken. The fate of 40-50 mg/l bromacil and dimethoate, either on their own or in the presence of each other, in soil or culture solution environments in the absence of plants, was investigated. The environments were suspensions of a soil in which citrus has shown the phytotoxic interaction, filtered soil extracts (water-soluble components) inoculated with soil micro-organisms from the citrus soil or sterile, and sterile Hoagland's solution. The two sterile treatments were for an assessment of chemical degradation in solutions, as opposed to degradation in the presence of micro-organisms, and in the case of soil suspensions, other particulate organic and inorganic soil components.

In the presence or absence of dimethoate, bromacil was degraded slightly in the soil suspensions, with half-lives ranging from 164-284 days, but no degradation occurred in the non-sterile and sterile soil extracts or sterile Hoagland's solution. Dimethoate was degraded most rapidly in the soil suspensions, with the

highest dimethoate-degrading activity in 60% of the flasks that also contained bromacil. Half-lives for a slower first-order degradation of dimethoate ranged from 9-36 days. In other soil suspensions, with a higher wet soil content, and containing only dimethoate, half-lives ranged from 13-17 days. Dimethoate degradation rates in most inoculated and sterile soil extracts were similar, with half-lives of 18-24 days and 20-64 days, respectively.

Three inoculated soil extracts showed accelerated degradation of dimethoate after 30-59 days, indicating enrichment of dimethoate-degrading micro-organisms. Dimethoate was degraded the slowest in sterile Hoagland's solution, with half-lives from 46-177 days. A bacterial isolate (*Arthrobacter* species) obtained from a soil suspension rapidly degraded 50-250 mg/ℓ dimethoate in a basal mineral salt medium.

The rapid microbial, as well as non-biological breakdown of dimethoate in soil suspensions and extracts, were thus demonstrated unequivocally. The value of using inoculated and uninoculated filter-sterilised soil extracts were clearly demonstrated.

The fact that bromacil was barely degraded in the soil suspensions of this study provides the scientific basis for the recommendation of Dr Bot (Act 36 of 1947) that no dimethoate should be applied where bromacil has been used in previous years for weed control. As there was no evidence in the soil for an interaction that could give rise to the phytotoxic response, an explanation for the phytotoxic reaction was sought in the interaction of the pesticides with the citrus plant *per se*, and this constituted the following study.

In this study, less phytotoxicity occurred when bromacil and dimethoate were applied simultaneously to *Citrus jambhiri* plants than when dimethoate was applied alone. In either case, photosynthesis was inhibited, and the plasma membranes of the root cells were badly damaged. A bromacil and dimethoate treatment inhibited photosynthesis more than treatment with either of the pesticides alone. In plants treated with both pesticides, the plasma membranes were damaged to a lesser extent than when the two pesticides were applied separately. More (¹⁴C)bromacil was absorbed by the roots of plants treated only with bromacil than those treated with bromacil and dimethoate together. From this work, dimethoate appears to be responsible mainly for the phytotoxicity symptoms observed in plants treated with bromacil and dimethoate simultaneously.

• Biotesting

PB.2552 24 1 1:

THE USE OF AN ALGAL BIOASSAY METHOD TO DETERMINE CONCENTRATIONS OF PHOTOSYNTHETIC INHIBITING HERBICIDES. 1985-1988

C.J. Lombard

A variety of methods are available for the detection and quantification of total herbicide residues in soils. To determine many of the photosynthetic-inhibiting herbicides with conventional gas-liquid chromatographic techniques requires a large input of time, and expensive equipment. The analytical methods require derivation and extraction with organic solvents. Also, the use of organic solvents may not necessarily give an indication of what herbicide concentration in the soil would be biologically available. However, it is useful to know what percentage of the total residue is biologically available to plants in order to predict possible damage to subsequent crops and to the environment in general. For this a bioassay technique would be required. There were many bioassays that could be used to determine herbicide residues, but were considered unsuitable as they did not fulfil the necessary prerequisites. These were that the bioassay had to be quantitative, rapid, and provide a direct measurement of herbicide injury.

Thus the influence of a photosynthetic-inhibiting herbicide bromacil (the active ingredient in Hyvar-X) on the net photosynthetic oxygen production of a unicellular green alga *Selenastrum capricornutum* was investigated with a view to developing a rapid quantitative bioassay to determine herbicide residues in the field (Bennett & Sandmann, 1983). Bromacil was chosen because its mode of action was well-documented and because it is such a strong photosynthetic inhibitor.

The method that was developed was rather preliminary in its working and basically consisted of culture vessels inoculated with the alga *Selenastrum capricornutum* which received sterile air with a 4% carbon dioxide content. When the algal culture was at the correct growth stage, it had to be diluted after which it was de-oxygenated and received 1 ml of the aqueous solution of bromacil. Oxygen readings were then taken at time zero and after 1 h using an Orion oxygen electrode.

A dose-response curve was established, using concentrations of bromacil ranging from 10 and 100 ug/ℓ. An index of herbicide injury was calculated. The purpose of this index was to enable the injury caused by the herbicide to the algae to be expressed as an arbitrary figure rather than as an oxygen production value.

The method showed the suitability of using the alga *Selenastrum capricornutum* in a bioassay for bromacil but there were some drawbacks. First, the level of inhibition produced by a certain concentration of

bromacil would vary considerably from experiment to experiment. Secondly, the large volume of suspension that had to be used with the oxygen electrode was undesirable as it led to inaccuracies. Finally, the simple culture method could not provide the volume of algal suspension required for analyses, as well as a growth rate that could be controlled effectively.

The aim of the next study (Bennett & De Beer, 1984) was to develop a technique whereby biologically available bromacil residues in soils could be determined on a routine basis and to evaluate the method by comparing its results with those obtained using gas-liquid chromatography. A highly successful continuous culture system had been developed, replacing the previous crude system (Bennett & Sandmann, 1983). The whole infrastructure accompanying the continuous culture system was also new. A peristaltic pump was set to deliver sterile basal medium into the culture vessel at a specific rate. The culture vessel, which received air enriched as before with carbon dioxide, was sandwiched between 2 banks of fluorescent tubes which supplied the correct light intensity so necessary to maintain the algal culture in the logarithmic growth phase.

A dose-response curve was again set up but this time using a Rank oxygen electrode. Only 4 ml [(instead of 350 ml used previously (Bennett & Sandmann, 1983))] of the algal suspension was used with 1 ml of the aqueous bromacil solution. After de-oxygenating the mixture, the net oxygen production by the algae was measured on a recorder over the next 5 min.

In the dose-response curve, the relationship between bromacil concentration and the percentage reduction in oxygen production was linear between 0.2 and 1 mg bromacil per litre. Biologically available bromacil residues in soils were successfully determined by obtaining a clear aqueous extract from a soil fortified with a known amount of herbicide. Samples of these extracts were added to the algal suspension. The concentration of biologically available bromacil was determined by reference to a previously established dose-response curve. The accuracy of this bioassay was determined by comparing the results with those obtained using capillary gas-liquid chromatography. The results obtained by the two different methods showed good agreement.

In conclusion, the method of Bennet & De Beer (1984) provides a simple algal culture system which produces a continuous supply of culture that is in the logarithmic phase and the method is rapid in the routine analyses of soils fortified with bromacil.

• Chemistry

PB.2552/53/1/2:

IMPROVEMENT OF CHROMATOGRAPHIC RESOLUTION OF PESTICIDES. 1981-1987
P.R. de Beer

The purpose of this facet was to investigate various means to improve chromatographic resolution of pesticides.

Initially it was planned to couple two packed columns, placed in separate gas chromatographic ovens, sequentially. By operating the ovens at different temperatures, it was hoped to obtain better resolution between co-extractive peaks and pesticide peaks. This technique, however, was abandoned because of shortage of instruments.

Capillary columns (wall coated open tubular columns) was then evaluated for resolution and absolute quantification of pesticides. The technique proved to be extremely powerful in respect of resolution and acceptable in absolute quantification. Unfortunately, column resolution deteriorated rapidly with the introduction of co-extractives and a pre-column system was developed to counter the contamination of the column. The pre-column system proved to be very temperamental and difficult to operate under routine analysis conditions and refining of the system was necessary.

Meanwhile wide bore open tubular columns came on the market which were vastly superior to packed columns in respect of resolution and were not prone to contamination by co-extractives. These columns were implemented in the routine analysis of pesticides and the further development of a pre-column system for capillary columns was not pursued any further.

Further work done under this facet was the generation of relative retention data for pesticides. Several publications contain relative retention data for pesticides on packed columns, but many of the pesticides have since been withdrawn from the market whereas others have appeared. The lack of any description of peak shape, optimum carrier gas flow rates, column lengths and temperatures was regarded as important deficiencies in all previously published relative retention indices.

ANIMAL PRODUCTION PROMOTION

ANIMAL PRODUCTION AND ANIMAL PRODUCTS RESEARCH

Animal production

BEEF CATTLE

- *Upgrading*

VS.3111/07/1/5:

UPGRADING STUDIES OF BEEF CATTLE: A GENETIC STUDY OF THE 1/29 CHROMOSOME TRANSLOCATION IN THE PROGENY OF A HETEROZIGOTE BRAHMAN BULL. 1985-1987
N.D. Nel

During routine screening, a Brahman bull from the Artificial Insemination (AI) Co-operative was found to be a carrier of the 1/29 chromosome translocation; a fusion between chromosomes from pairs one and 29. At the time, this three-year-old bull had been in service for approximately 18 months, and 14 000 doses of frozen semen had already been sold.

In view of the reported effect on fertility, this discovery was seen in a serious light. In conjunction with the Brahman Cattle Breeders' Society of South Africa, it was decided to trace the origin and spread of the anomaly in South Africa and to investigate the possible effect of the translocation on fertility and growth. Information supplied by the Breeders' Society and the AI Co-operative was used to locate progeny produced from the sale of affected semen.

The presence of the anomaly was confirmed in 78 offspring and other family members found on 15 farms. A random sample from the general Brahman population revealed a total absence of any translocation carriers in unrelated families. The results, together with the information supplied by the Co-operative show that most of the semen was sold to commercial cattle breeders and as such poses little threat to the stud industry.

The investigation showed that the anomaly was probably introduced into the South African Brahman Cattle via cattle imported from the United States of America during the early 1960's.

The results of the analysis of variance, comparing the growth rates of normal and translocation sibs, showed a non significant mass advantage in favour of the translocation carrier animals.

The extensive farming conditions and the lack of reliable data under such conditions did not allow for a meaningful statistical analysis of fertility. In the absence of evidence to the contrary, it is necessary to accept that the presence of the translocation causes a reduction in the fertility of carrier animals.

The findings of this research facet together with a set of recommendations have been submitted to the Brahman Cattle Breeders' Society of South Africa.

DAIRY CATTLE

- *Nutrition*

VS.3112 05, 1, 8:

DAIRY CATTLE NUTRITION: THE POTENTIAL OF PHYLLOSILICATE (PHALABORWA VERMICULITE) AS BUFFER IN DAIRY CATTLE DIETS. 1986-1988
L.J. Erasmus

The inclusion of buffers like sodium bicarbonate (NaHCO_3) and magnesium oxide (MgO) in the diets of early lactation cows in order to help prevent milk fat depression and lower fiber digestibility, is well documented and accepted by dairy nutritionists and researchers. Research is ongoing to identify cheaper mineral buffers that exhibit the same mode of action as the established buffers. One such a mineral is vermiculite, as it exhibits a very high cation exchange capacity. This study was conducted to establish whether Phalaborwa vermiculite (grade MCF) can replace NaHCO_3 , partly or totally as buffer in dairy cattle diets and to study the effects of vermiculite and NaHCO_3 additions on intake, milk production and composition, digestibility, rumen fermentation characteristics, serum mineral concentrations and liquid flow rates when added to a milk fat depressing diet.

Four rumen-fistulated Friesian-Holstein cows in mid-lactation received a high concentrate complete diet *ad libitum* for 3 weeks prior to and throughout the study. The basal diet contained 70 % concentrate and 30 % finely chopped (± 1 cm) *Eragrostis curvula* hay. The experimental design was a 4 x 4 Latin square with 33 days in each period allowing the first 14 days for adaptation and the last 19 days for sampling and the digestibility study. Treatments were:

1. basal diet
2. basal + 0,6 % NaHCO_3 + 1,8 % MCF
3. basal + 1,2 % NaHCO_3
4. basal + 3,6 % MCF.

All supplements are a percentage of total dry matter of the diet.

Dry matter intake and milk production data are presented in Table 1. There were no significant effect ($P > 0,10$) of either NaHCO_3 or MCF inclusion on milk production or dry matter intake, but there was a strong tendency for the NaHCO_3 supplemented diets to correct a low milk fat test. This study also suggests that 1,2 % NaHCO_3 in the total diet is probably too high as both treatments with NaHCO_3 gave similar production results.

TABLE 1. Dry matter intake, milk production- and composition as affected by buffer treatment

Measurement ¹	Treatments				SE
	1 Basal diet	2 0,6 % NaHCO_3 + 1,8 % MCF	3 1,2 % NaHCO_3	4 3,6 % MCF	
Dry matter intake (kg/d)	18,1	17,0	18,2	18,4	0,46
Milk production (kg/d)	19,3	19,4	19,8	18,7	0,64
Milk fat (%)	3,33	3,59	3,62	3,32	0,12

¹ No significant differences between treatments for any of the measurements ($P > 0,10$)

Means of some ruminal measurements are shown in Table 2. Sodium bicarbonate increased ruminal pH and buffering capacity but MCF failed to do so when compared to the basal diet. The addition of 1,2 % NaHCO_3 resulted in the highest rumen molar percentage of acetate and reduced the propionate significantly ($P < 0,05$) when compared to the MCF treatment. This resulted in a significantly higher acetate: propionate ratio. The 1,2 % NaHCO_3 treatment also increased the liquid dilution rate significantly ($P < 0,05$) when compared to the basal diet. The results from this study clearly supports the concept that the mode of action of NaHCO_3 is to elevate rumen pH and increase outflow of rumen fluid to the small intestine. This decreases the amount of propionic acid produced in the rumen and increase milk fat test.

TABLE 2. Means of some ruminal measurements as affected by buffer treatment

Measurement ¹	Treatments				SE
	1 Basal diet	2 0,6 % NaHCO_3 + 1,8 % MCF	3 1,2 % NaHCO_3	4 3,6 % MCF	
Rumen fluid pH	5,75a	5,89ab	5,95b	5,80ab	0,04
Buffer capacity (m/ 1N HCl/m/ rumen fluid)	0,33a	0,37ab	0,40b	0,36ab	0,03
Acetate: Propionate ratio	2,08cd	2,16cd	2,38c	1,82d	0,11
Rumen fluid dilution rate (%/h)	10,9a	11,5ab	12,1b	11,6ab	0,19

¹ ab Means in same row with different superscripts differ significantly ($P < 0,05$)

cd Means in same row with different superscripts differ significantly ($P < 0,10$)

No significant effect of buffer treatment were found on serum mineral concentrations or nutrient digestibility coefficients. Although fecal pH was significantly increased ($P < 0,05$) by the addition of 3,6 % MCF, it could not be related to changes in starch digestion. This study supports the findings of other researchers who demonstrated the variability of fecal pH measurements and posed a question on the validity of measuring pH by electrode in fecal samples.

In conclusion, under the conditions of this study, vermiculite did not show any promise as a buffer, whereas NaHCO_3 once again proved to be an effective buffer, even mid-lactation cows receiving a diet not based on corn silage, proved the effectiveness of NaHCO_3 as a buffer.

MEAT GOATS

• Reproduction

VS.3117/04/1/2:

REPRODUCTION OF THE MEAT GOAT: BOER GOATS. 1980-1988

J.P.C. Greyling

Following an intensive macroscopical and histological study into the involution process of the *post partum* uterus of the Boer goat doe, the process was found to be completed by day 28 following parturition. The first new *post partum* corpora lutea are observed 32-34 days after parturition and are micro-morphologically approximately 15 days old, i.e. ovulation (without overt oestrus) had occurred approximately 17 days following parturition.

Regarding puberty and the induction of puberty, Boer goat female kids weaned during the breeding season exhibited puberty significantly earlier than those weaned outside the breeding season (157,2 versus 191,1 days, respectively). From the serum LH levels it is evident that the pituitary of the pre-pubertal female is already active from weaning (13 weeks of age) irrespective of the season, male effect or level of nutrition. No significant correlation could be found between mass and the age of the demonstration of first oestrus.

The sex activity in the Boer goat doe reaches its peak in autumn (April, May) and its low in late-spring to mid-summer (October to January) and can be seen as poly-oestrous, with an extended breeding season. A significant negative correlation was recorded between sex activity and daylight length in the adult doe.

The duration of the normal oestrous cycle was monitored as 20,7 days. Peak progesterone levels ($\pm 5 \text{ ng/ml}$) were reached by day 13 of the cycle, with a rapid drop during the last 3 days of the cycle. A mean oestrous period of 37,4 hours was recorded with an ovulation rate of $1,81 \pm 0,91$ ovulations per doe. The position of the LH peak varied between 4 and 20 hours following the onset of oestrus. By 38 hours after the onset of oestrus, 86,7 % of does had ovulated. The *post partum* anoestrous period was significantly shorter for does kidding in the breeding season (mean of 37,3 versus 59,9 days outside the breeding season). Similar to gestation length (mean 148,2 days) the number of offspring had no significant effect on the *post partum* anoestrous period.

The Boer goat doe reacted well to certain synchronisation techniques. The administration of intravaginal progestagen sponges for a period of 12-18 days in the breeding season, showed the longer progestagen treatment to have a significant shorter response time. The duration of the induced oestrous period was 30,6 hours compared to a mean of 37,4 hours during the natural oestrous period. Occurrence of the LH peak was synchronised at $11,0 \pm 3,7$ hours following the onset of oestrus. The route of PMSG administration (subcutaneous or intramuscular) had no significant effect on the efficiency of synchronisation. The administration of PMSG as such did, however, significantly shorten the time from sponge withdrawal to oestrous.

The use of the double prostaglandin injection regime (62,5-250 μg per injection) is very effective in synchronising oestrus in the Boer goat doe during the breeding season. Administration caused rapid luteolysis and serum progesterone levels of under 1 ng/ml within 24 hours. However, outside the breeding season, the use of the double prostaglandin regime is not effective, because of inactive corpora lutea. The use of intravaginal progestagen sponges (14 days) or intravaginal progestagen sponges (8 days) plus prostaglandin, with 500 IU PMSG is very effective outside the normal breeding season. The mean conception rate following AI for the respective synchronisation techniques was 73,3 and 66,7 %, respectively.

PIGS

• Reproduction

VS.3119/04/1/3:

THE SYNCHRONISATION OF PRE-PUBERTAL GILTS. 1982-1988

G.W. Kay

Twenty-six Large White x Landrace gilts, aged 125 days, were fitted with polyvinyl chloride indwelling jugular catheters. Catheters, 120 cm long, were supplied with a locating cuff 20 cm from the internal end and inserted into the right atrium via the jugular vein. The loose end of the catheter was exteriorised on the gilt's shoulder, fitted with a three-way stopcock and suspended above the gilt with a pulley and counterweight system to facilitate repetitive blood sampling. Catheters were serviced with a saline solution containing 250 I.U. heparin/ ml once in 24 hours or after each withdrawal of blood.

At 150 days of age, the 12 gilts whose catheters were still functional were randomly divided into two groups of six each. Group one was stimulated once daily for one hour by exposure to a mature boar. Three different boars were used in rotation. In group two the boar stimulus was simulated by stimulating gilts with an olfactory stimulus consisting of boar urine, semen and saliva. The stress factor was simulated by intravenous injections of insulin daily (50:50 mixture of normal and long acting insulin). The gilts were in the same building as group one to ensure the same auditory stimulation. Six half-hourly blood samples were collected each day, one before and five after each stimulation. Blood samples were analysed by RIA once weekly for progesterone and estrogen to verify visual oestrous observations. Cortisol was similarly monitored as an indicator of the stress response to stimulation.

The average age at first estrous was 187,8 and 228,7 days for groups one and two, respectively (significantly different at $P < 0,01$). Group two displayed significant rises in blood cortisol and progesterone levels after stimulation each day. Cortisol and progesterone were not significantly affected in group one. Variations in estrogen levels during and after stimulation were not observed, probably because it was below the sensitivity level of the RIA analysis. It was concluded that the simulation as described was not representative of the boar effect.

VS.3119/04/1/4:

REPRODUCTION OF BOARS: INFLUENCE OF SEASON. 1982-1988

G.W. Kay

Semen was collected three times per week for 3 adult boars over a period of 13 months. During this period, the highest maximum and minimum daily temperatures were 27,7 °C and 15,2 °C, respectively and occurred in January.

On the parameters monitored which included sperm motility scoring, ejaculate volume, gel volume, sperm concentration, pH and fructose concentration, only a minimum in semen pH and a maximum in the concentration of fructose was seen to coincide with the summer peak temperatures. These conditions were not unique to summer and also occurred in April/May and, therefore, it seems unlikely that they account for summer infertility.

• Nutrition

VS.3119/05/1/9:

PIG NUTRITION: A COMPARISON BETWEEN THE MOBILE NYLON BAG TECHNIQUE AND THE TOTAL COLLECTION OF FAECES TO DETERMINE DIGESTIBLE ENERGY VALUES. 1986-1988

T.S. Brand

Generally the feeding cost amounts to approximately 70 to 80 % of the total cost of pig production. The type of ingredient used in the formulation of the diet plays an important role in the feed cost, however, also important is the digestibility and quality of the individual feedstuffs used. Determination of the digestible energy content (DE) of feedstuffs using conventional techniques, requires a large number of animals, a large quantity of feed, and considerable expenditure on equipment and manpower. A rapid and a less expensive technique for determining the DE content of feedstuffs was, therefore, needed.

Recent work has shown that the digestion of feed samples, contained in nylon bags and passed through the gastro-intestinal tract of pigs, could be used in the rapid determination of feed quality (Pettry & Handlos, 1978; Sauer, Jorgensen & Berzinz, 1983). Several authors, however, found that the mobile nylon bag technique (MNBT) underestimates dry matter (DM) and energy digestibility (Taverner & Campbell, 1985; De Lange, Sauer, Den Hartog & Huisman, 1987; Sauer, 1986) of feedstuffs. Sample size, degree of fineness of the grind, the basal diet, retention time of the bags and the possibility of faecal contamination of residues in bags were contributory factors.

A factorial design (2 x 3 x 3) with 16 bags per treatment were used to define the effect of washing, time of pre-digestion and particle size of the feed samples on the DE values as determined by the MNBT. Two hundred and seventy bags (25 x 40 mm) with a 53 µm mesh size were used. One gram feed samples, milled through a mill with sieve sizes of 800 µm, 1 mm and 3 mm were placed into the bags. Prior to insertion the bags with the samples were predigested in a waterbath at 37 °C with 0,01 N HCl and 1 g/l pepsin for 0, 2,5 and 4 hours, respectively. The bags were randomly inserted through duodenal cannulas and collected in the faeces at 4 hour intervals. Half of the retrieved bags were immediately washed in cold water, while the other half remained unwashed. Following freeze-drying the bags were cut open and DM and gross energy (GE) content of the residue in each bag was determined. Conventional DE values were obtained by the total collection of faeces technique (Siebrits & Ras, 1981).

The retention time of the bags with feed samples were compared to feed samples marked with 51 Cr-mordant, using the method described by Pienaar & Roux (1984). Two diets with respectively, 2% and 8% crude fibre content, were used to determine the effect of crude fibre of the basal diet on the MNBT DE value. In two further treatments pigs were respectively fed a high- and low tannin diet, whereas a high tannin sorghum sample was placed into the bags.

Retention time and pre-digestion time had no effect on DE. DE values obtained with unwashed bags (13,57 MJ/kg) were highly significantly ($P < 0,01$) lower than DE values obtained with washed bags (15,01 MJ/kg), and values obtained with the conventional technique (14,87 MJ/kg). Particle size plays an important role, however, the DE values obtained with the washed bags, for the different particle sizes, differ non-significantly from the reference DE value (14,87 MJ/kg). DE values from material with the 3 mm particle size (14,52 MJ/kg) were highly significantly ($P < 0,01$) lower, and DE values with a 800 μ m particle size (15,49 MJ/kg) significantly ($P < 0,05$) higher, than the DE value obtained with the 1 mm particles (15,02 MJ/kg). The 1 mm particles had the best correlation with the reference DE value and differed by only 1,0%. Washed bags, irrespective of pre-digestion, milled through a 1 mm sieve size were best correlated with the reference DE value. According to a graph of DE versus particle size of the samples in the bags, a particle size of 1,16 mm would obtain the exact DE value as obtained by the conventional technique.

The basal diet affected the DE value obtained with the MNBT and a high crude fibre level (8%) in the diet lead to a lower DE value (14,53 MJ/kg) than the DE value (15,17 MJ/kg) obtained with a low fibre (2%) diet. With high tannin feed samples in the bags, the DE value obtained with a low-tannin basal diet (14,25 MJ/kg) was higher than the DE value obtained with a high-tannin basal diet (13,81 MJ/kg).

From this study, it can be concluded, that the MNBT lend it excellent for the evaluation of grain, especially where a lot of samples had to be evaluated. However, the basal diet effected DE values and must be carefully standardised.

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VS.3119/05/1/10:

PIG NUTRITION: THE EFFECT OF THERMAL AMMONIATION ON THE DIGESTIBILITY AND UTILISATION OF BIRD-PROOF GRAIN SORGHUM. 1987-1988

T.S. Brand

Some grain sorghum production areas in South-Africa are exclusively suitable for the production of bird-proof grain sorghum (BPS) varieties. The feedmarket, however, discriminates against BPS, because of the negative influence of tannin on animal production (Kemmer, Ras & Daiber, 1984). BPS cultivars contain 5 to 25 times more tannin than normal yellow endosperm sorghum cultivars (Daiber & Van Bellinghen, 1976).

Recently great progress was made with the ammoniation of BPS to neutralise the detrimental effects of tannin (Price, Butler, Rogler & Featherston, 1979; Reichert, Flemming & Schwab, 1980; Ford & Hewitt, 1979). Swiegers (1987) described a process of thermal ammoniation with the commercial An-Stra-Verter^R oven. He found that ammoniation at a 1,5% NH₃ level reduced the tannin content of BPS from 1,33-0,33% and improved in vitro digestibility by 6%.

In this study sorghum with a polyphenol content of 1,24% was used. The sorghum was milled through a 3-mm screen, divided into three batches and treated as follows:

1. BPS (no treatment applied).
2. BPS thermally ammoniated in a commercial An-Stra-Verter^R oven (NH₃BPS) at a level of 15 g NH₃/kg/DM.
3. The same process as in 2, but no ammonia gas was let into the chamber (HBPS).

A first experiment was conducted to determine the effect of heat treatment and thermal ammoniation on dry matter digestibility, true lysine and true methionine availability and true metabolisable energy content of BPS in a digestion trial with roosters and to determine the relative nutritive value of the different test components in a slope ratio assay with rats. Thermal ammoniation reduced the tannin content of high-tannin components in a slope ratio assay with rats. Dry matter (DM) digestibility, true grain sorghum by 55.1%, whereas heat treatment *per se* had no effect. Lysine and true methionine availability and true metabolisable energy content were significantly ($P \leq 0.01$) improved by 4.7, 25.0, 51.3 and 8.9% by thermal ammoniation, respectively. Heat treatment reduced the true lysine and true methionine availability significantly ($P \leq 0.01$) by 9.1 and 20.8%, respectively. In the slope ratio assay with rats, no significant differences were obtained in the relative nutritive value of the test components.

In a second experiment (with pigs) the effect of thermal ammoniation and heat treatment of BPS on N retention, digestible (DE) and metabolisable energy (ME) content, apparent and true faecal and ileal amino acid digestibility was determined in a 4 x 4 Latin square experimental design. Ileal digestibility was determined with ileo-rectal anastomosed (IRA) pigs. A nitrogen-free source (NFD) consisting of maize starch mixed with wheat straw to contain the same crude fibre (CF) content as BPS was used to correct the protein digestibility values for endogenous N contribution. A growth trial was carried out with 20 pigs to evaluate the effect of NH_3BPS and BPS in the diet on the performance of growing pigs.

DM digestibility, energy digestibility, DE and ME content of BPS were significantly ($P \leq 0.05$) improved by 5.5, 8.3, 12.7 and 12.4% by thermal ammoniation, whereas the ileal digestibility values of DM and energy and the DE and ME content were respectively increased by 10.8, 14.3, 18.6 and 19.6%. Heat consequently led to an improvement of 5.8, 9.1, 12.7 and 14%. Apparent digestibility of N was improved significantly ($P \leq 0.05$) by 17.9% with ammoniation, whereas the apparent ileal digestibilities of HBPS and NH_3BPS were increased significantly ($P \leq 0.01$) by 101.6 and 158.8%. The same trend was observed in the case of true digestibility values. Apparent and true N retention increased respectively from 5.2 to 5.9 g/day and from 7.9 to 8.7 g/day owing to ammoniation. Apparent ileal N retention increased significantly ($P \leq 0.01$) from -4.3 to 3.4 and 3.8 g/day, whereas true ileal N retention increased from 0.16 to 7.3 and 8.3 g/day for HBPS and NH_3BPS .

The mean endogenous protein secretion for the surgically modified (12.1 g CP/day) and normal pigs (6.01 g CP/day) differed significantly ($P \leq 0.01$). A net synthesis of isoleucine, lysine and methionine was observed in the large intestines of pigs fed the sorghum diets. In general, the mean apparent and true faecal and ileal digestibilities of amino acids (AA) were the highest for NH_3BPS , followed by HBPS and BPS. Thermal ammoniation improved the true ileal digestibility (as measured with IRA pigs) of arginine (28.3%), methionine (22.9%), valine (42.8%), histidine (22.9%), isoleucine (8.8%), lysine (27.3%), phenylalanine (27.3%), threonine (24.6%), serine (17.0%) and tyrosine (6.9%). Although ammoniation improved AA digestibility, the improvements were too small to be of practical importance considering the possibility of denaturation of proteins and AA with heat treatment.

It can thus be concluded, that thermal ammoniation of high tannin sorghum, as used in this study, would not be profitable and is not recommended as a method to improve the nutritive value of BPS for pigs. However, it is possible that ammoniation at a lower treatment temperature and/or a higher moisture level may have an advantageous effect on the nutritive value of BPS, considering the reduction of tannin content obtained by ammoniation.

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CHICKENS

• Nutrition

VS.31110/05/1/4:

THE USE OF *SORGHUM VULGARE* AS AN ENERGY SOURCE IN BROILER DIETS.
1982-1989

G.M. Schutte

The nutritional value of sorghum grain (GL) and yellow maize have a remarkable resemblance in terms of chemical and biological parameters. Grain sorghum, however, differs from yellow maize by being deficient in xanthophyll.

A comparative study with broilers where NaOH- and formaldehyde-treated bird-proof sorghum were investigated as the basic energy source in the diet. Tannic acid in bird-proof sorghum can effectively be removed by NaOH- and formaldehyde treatment.

Live mass gain up to 21 days of age can be improved by 12 % and 9 % with NaOH- and formaldehyde treatment, respectively. Feed efficiency was improved 7 % by these two treatments.

Both these treatments caused amino acid damage and the optimum treatment lies delicately between the destroying of tannic acid and amino acid damage.

The replacement of yellow maize by sorghum in broiler starter and/or finisher diets was studied. The study was conducted to determine whether low tannin sorghum (GL2) could replace yellow maize partially or fully in broiler starter and/or finisher diets. It was also determined whether there is any specific replacement ratio between sorghum and yellow maize where a complimentary effect could occur.

It was concluded that sorghum can replace yellow maize partially or fully on a nutritional basis without any significant effects on live mass or feed efficiency.

There was also a remarkable resemblance in terms of chemical- and biological parameters between yellow maize and sorghum (GL). The use of sorghum and yellow maize can thus be fed as determined by formulation of a least cost diet, especially if live mass and feed efficiency are used as production parameters. It must also be taken into consideration that broilers that are fed sorghum-based diets have little skin pigmentation when compared to broilers fed maize diets.

Broiler production on milled and unmilled sorghum diets was compared. A study was undertaken to determine whether it is essential to mill sorghum before it is included in broiler diets since remarkable savings can be achieved if unmilled sorghum can be included in broiler diets without detrimental effects occurring on live mass or feed efficiency.

It was found that unmilled sorghum significantly reduced feed efficiency during the starting period. The broilers, however, compensated fully for this draw-back during the finishing period. If broilers are slaughtered at 42 days of age unmilled sorghum had no effect on broiler production in terms of live mass gain and feed efficiency. There was a tendency, although not significantly so, of a higher live mass in broilers fed the unmilled sorghum.

Preferences of the South African consumer regarding broiler skin colour and the inclusion rates of synthetic carotenes in sorghum-based diets were investigated. Results showed that broiler skin colour can be manipulated successfully by the inclusion of synthetic carotenes to sorghum based diets.

Supplementation with carotenes is essential in order to produce a broiler skin colour that is acceptable to the South African consumer.

It was further established in this study that carotene supplementation can be used successfully to manipulate broiler skin colour even if it is only supplemented during the finishing period.

Animal products

MEAT

• Norm studies

VS.3121/50/1/12:

MEAT AND MEAT PRODUCTION NORM STUDIES: THE INFLUENCE OF VACUUM
PACKAGING FILMS ON BEEF QUALITY. 1986-1989

H.F.O. Bekker

The research in this thesis dealt with the influence of different vacuum packaging films on the physical

characteristics and microbiological quality of either cold- or hot-boned beef, stored and displayed for different periods.

All the films used in this trial (OTR range 1,33 to 49,8 ml/m²/24 h by 23 °C and 75 % RH) were successfully applied regarding colour and general acceptability in the vacuum packaging of fresh meat. The films with the lowest OTR were more suitable, whereas the use of films with a thermal shrinkage ability (memory) resulted in less percentage drip loss ($P < 0,01$). It was once more confirmed that meat can be stored in vacuum for even longer than 21 days, without any significant discolouration whereas the eating quality (tenderness and aroma) of the product is enhanced.

The tenderness and the microbiological quality of the meat were not significantly affected by hot boning in combination with electrical stimulation.

VS.3121/50 1 13:

EFFECT OF SEVERAL MICROWAVE AND CONVECTION OVEN ROASTING METHODS COMPARED TO A CONVENTIONAL ROASTING METHOD ON THE SENSORY AND PHYSICAL QUALITY CHARACTERISTICS OF BEEF *Mm LONGISSIMUS THORACIS ET LUMBORUM* CUTS. 1986-1988

J.S. le Roux, I.B. Zondagh and M.E. Prinsloo

The effects of five different cooking, roasting methods on eating quality, cooking losses and proximate chemical analysis of 32 beef *Mm longissimus thoracis et lumborum* cuts were evaluated. The heat treatments consisted of roasting the 16 paired 2-kg cuts in a microwave-convection-simultaneous-combination oven, a microwave-convection-intermittent-combination oven, a microwave oven, a convection oven roasting method, as compared to a conventional oven (control). Sensory evaluation (internal and external colour, tenderness, juiciness, flavour), objective cooking loss data, water holding capacity (WHC), shear force measurements and proximate analysis (total moisture, fat, protein and ash) were done on all the samples.

Results of eating quality characteristics, WHC and shear force measurements did not differ significantly from the conventional oven, except for sensory juiciness. Here the control done in the conventional oven was found to be more juicy (mean value of 3,94) than the simultaneous-combination oven (mean value of 2,99), with scores of 1 being considered to be the least and 6 the most juicy.

The total cooking losses showed statistically significant differences ($P < 0,05$), with greater losses incurred for the three microwave-based methods. The average total cooking losses are as follows:

- conventional, 23,45 % versus microwave, 33,75 %;
- conventional, 25,28 % versus simultaneous-combination oven, 40,45 %; and
- conventional, 25,38 % versus intermittent-combination oven, 27,62 %.

The drip loss also showed statistically significant differences ($P < 0,01$), with greater losses incurred for the three microwave-based methods. The average drip losses are as follows:

- conventional, 8,08 % versus microwave, 10,62 %;
- conventional, 7,83 % versus simultaneous-combination oven, 14,87 %; and
- conventional, 7,81 % versus intermittent-combination oven, 12,87 %.

The evaporation loss also showed statistically significant differences ($P > 0,05$), with greater losses (17,57 %) found with the conventional oven as opposed to the intermittent-combination oven (14,75 % loss).

The general conclusion is, therefore, that larger (2 kg raw mass) beef cuts can be roasted successfully in these microwave-based ovens, although greater cooking losses occurred when the latter were used. This results in a lower yield in the cooked product. The longer cooking times required for these bigger roasts also result in an improvement in their external colour, as opposed to, for example, steaks, being microwaved for shorter times.

VS.3121/50/1/14:

COMPARISON OF THE QUALITY CHARACTERISTICS OF GOAT MEAT WITH THOSE OF SHEEP MEAT. 1986-1989

H.C. Schönfeldt

The purpose of this study was to ascertain how the quality characteristics of Angora and Boer goat meat compare with those of sheep meat. The quality characteristics of the *Mm longissimus thoracis et lumborum* of the various age groups and fat codes of Angora and Boer goat meat, prepared according to a dry heat cooking method, were compared with those of the identically prepared *Mm. longissimus thoracis et lumborum* of the corresponding age groups and fat codes of sheep meat. Thereupon the quality characteristics of the *M. semimembranosus* of the various age groups and fat codes of Angora and Boer goat

meat, prepared according to a moist heat cooking method, were compared with those of the identically prepared *M. semimembranosus* of the comparable various age groups and fat codes of sheep meat. Triplicate sets of comparable cuts from each age group and fat code were evaluated, thus 27 sheep, 27 Angora and 27 Boer goats were compared.

This study confirms that goat meat is unique and should not be grouped with meat from comparable sheep having the same maturity and fatness levels with regard to palatability attributes. Significant differences exist between the quality characteristics of sheep on the one hand, and Angora and Boer goat meat on the other. The aroma of the sheep meat is more intense, it is more juicy, more tender, contains less fibrous tissue residue and the species flavour is more pronounced (typical) than that found in Angora and Boer goat meat. In general, the meat from goat carcasses was found to be significantly less acceptable than that from sheep carcasses, the Angora to a lesser extent, however, than the Boer goat.

As was anticipated, this study confirms the fact that the *meat of younger animals* is more juicy, more tender, contains less fibrous tissue residue during chewing and the species flavour is less typical than that of older animals. This was irrespective of the fact whether it was obtained from sheep, Angora or Boer goat.

Significant differences in the palatability attributes were found with an increase in the fatness (fat codes) of the animals. With increasing fatness the juiciness of the cooked cuts tended to decrease and the tenderness and species flavour to increase.

VS.3121/50/1/17: CARCASS AND MEAT QUALITY CHARACTERISTICS OF INTACT AND CASTRATED MALE CATTLE. 1987-1988
T. Pietersen

The research in this dissertation deals with the influence of sex condition on carcass and meat quality characteristics of bovines. Secondary sexual development is a sign of physiological maturity within a chronological age group. Reclassification of intact males with prominent secondary sexual development to an older age group is stipulated by the official grading regulations for beef carcasses in South Africa. This is based on the belief that meat from animals exhibiting secondary sexual development has a lower consumer acceptability at the retail level than that of animals without this development or of steers. This is traditionally believed to be due to differences in tenderness, colour, texture and fat distribution.

Differences in carcass composition and meat quality traits between the following were investigated:

- (a) bulls with secondary sexual development,
- (b) bulls without this development and
- (c) steers.

Animals of the same synthetic line and in the A-age group (no permanent incisors), but in two different mass groups were used. Various body and carcass measurements were taken, and the carcass composition of the animals was determined. Biochemical and proximate analyses, as well as sensory and colour evaluations of the meat were conducted.

Differences between the sex condition groups in the muscle development of the forequarters were found especially in the neck and shoulder regions. These differences were noticeable from the level of development of individual muscles right through to measurements taken on the live animal. Secondary sexual development code of the carcass and neck width on the live animal proved to be accurate predictors of carcass composition.

Differences in carcass composition were offset by the non-significance of differences in meat quality attributes, and of average retail prices of the carcasses. It is concluded that it is not justified to reclassify male animals falling in the A-age group, but showing prominent secondary sexual development, into an older age group.

DAIRY PRODUCTS

• Microbiology

VS.3124/08/3/4: ENTEROTOXIC *ESCHERICHIA COLI* IN DAIRY PRODUCTS. 1982-1987
H. Gavron

An overlay resuscitation-selective medium comprising of modified brain-heart infusion agar and double strength violet red bile agar containing the enzyme substrate 4-methylumbelliferyl- β -D-glucuronide was

developed. The medium proved to be efficient with regard to the total coliform count (102,5 % yield), and the direct enumeration of *Escherichia coli* (86 % of all typical colonies were *E. coli*) and other potentially pathogenic Enterobacteriaceae in milk and other dairy products. The medium also proved to be an efficient and rapid "go - no go" test with the presence of *E. coli* being indicated within 6-8 hours after inoculation.

- *Norm studies*

VS.3124/50/1/2:

THE QUALITY OF SOUTH AFRICAN ICE-CREAM. 1983-1988
J.J. Keller

A survey was done to determine the quality of South African ice-cream and ice-cream products. Of 340 dairy ice-cream samples tested, 99 % had total bacterial counts lower than 50 000 per gram (legal standard) and 73 % of the coliforms counts compiled with the legal standard of less than 10 per gram.

The counts for 275 sorbet samples were 92 and 56 %, respectively and for 266 milk ices and other ice-cream products the counts were 91 and 45 %, respectively. The average total solids percentage for dairy ice-cream, sorbet and milk ices were 34,35; 32,4 and 30,53 %, respectively. The average fat percentage for these products were 9,8, 7,16 and 7,96 %, respectively, for protein 3,28, 3,07 and 2,8 % and for ash 0,73, 0,67 and 0,64 %. Off-flavours were rare and the quality in general was excellent.

- *Technology*

VS.3124/52/1/9:

THERMISATION OF MILK FOR THE MANUFACTURE OF CHEESE. 1985-1987
T.E.H. Downes and G.J. Swart

The effects of raw milk thermisation, prior to storage, on psychrotrophic counts, as well as on fat, protein and total solid losses during Cheddar cheese manufacture, were studied. As far as protein, fat and total solid losses are concerned, no significant differences were observed between cheese batches using raw, thermised and control-milk, respectively.

Thermisation (65 °C/15 s) reduced the total psychrotrophic count by 85 % on average and promoted the cold storage (5 °C) of cheese milk for at least three days.

Psychrotrophic bacteria (<100 000/ml) exhibited little proteolytic activity as reflected in the cheese yield and no lipolytic activity as reflected by organoleptic grading of the cheese. This was true for cheese manufactured from either raw milk stored at 5 °C or thermised milk stored at 5 °C.

Supporting animal research

ANIMALS

- *Nutrition*

VS.3133/05/1/11:

FEED INTAKE IN THE NUTRITION OF FARM ANIMALS: THE CHROMIUM MORDANT AS A PARTICLE MARKER. 1985-1989
J.P. Pienaar

The objective of this study was to compare two methods that were used to determine the mean retention time of feed particles in the rumen. The first is the well-known single dose marker method. The second is a method developed at ADSRI, Irene, and is normally called the steady state method (Pienaar, Roux, Morgan & Grattarola, 1980).

A further objective was to found a marker that would bind more tenaciously to feed particles than the rare earth metals. These tend to dissociate from feed in acid medium, and to bind to microbial cells (Combs, Shaver, Singh & Satter, 1984). The label should also not influence the rate of passage by changing feed particle density and digestibility as is done by the chromium mordant when large quantities of chromium (e.g. 10 %) is bound to the feed (Ehle, 1984).

Since the chromium mordant binds tenaciously to particles it was proposed that the ⁵¹Cr isotope of chromium, prepared at a high specific activity (10 m Ci/200 mg of sodium bicromate), is used to label the feed. That would ensure that neither particle density nor digestibility is significantly influenced by mordanting the feed with chromium.

Washing the labelled sample could also influence particle kinetics since it removes the highly digestible soluble fraction. Thus it was planned to remove the soluble fraction from the fraction bound to the particles by washing the samples after they have passed through the animal. The procedure was planned in this manner so that labelling the feeds should have the smallest possible effect on particle kinetics.

The facet was conducted as two experiments. The first experiment studied the binding of marker to different types of feed and also rumen digesta. The second experiment studied the *in vivo* passage of marker that was mordanted to feed from the rumen and hindgut of sheep.

Three feeds were used in the first experiment. They consisted of either lucerne, maize cob leaves or fishmeal. The roughages were hammermilled through a 3-mm sieve and labelled with ^{51}Cr which was combined with either 0%, 0.5%, 1% or 2% non-radioactive Sodium dichromate, as carrier chromium. Incubation was done at either room temperature or at 60°C for either 1, 6, or 24 hours. Recovery of the label from the particles after boiling the sample in neutral detergent solution as for NDF determination was determined, as well as the digestibility of the sample in a Tilley and Terry *in vitro* system.

Some of the soluble chromium which could be washed from labelled feed with McDougal's saliva, was also incubated with unlabelled feed in a Tilley and Terry *in vitro* system. After washing the sample as for the normal *in vitro* filtration, the amount of bound chromium was determined. The sample was also boiled in a neutral detergent solution, and the amount of chromium remaining on the feed after boiling and washing, determined.

The second experiment (*in vivo* experiment) was conducted with 16 Mutton Merino wethers fitted with large rumen cannulae and simple "T" shaped cannulae in the abomasum. Animals were kept in metabolism crates with self feeders which fed the animals every four hours. At one occasion labelled feed was supplied for 30 minutes in the feed troughs and abomasal digesta and faeces collections commenced immediately afterwards.

In terms of marker binding and digestibility (Experiment 1), the diets responded very differently on the two treatments, marker concentration and incubation time.

Binding of the label was not significantly influenced by incubation time on the fishmeal feed but very much so by chromium concentration. With regard to the lucerne, feed binding was influenced significantly by both carrier concentration and incubation time. On the maize cob leaf feed, binding was only influenced by incubation time and temperature. At room temperature only 3.1% of the label was retained, whereas at 60°C, 7% was retained on the maize cob leaves. The percentage marker retained, had a close negative relationship with the losses during boiling in neutral detergent solution. Thus the higher the losses of organic matter during boiling the less marker was retained.

In vitro digestibility was significantly decreased by the amount of the carrier chromium on the fishmeal feed only. Both the lucerne and maize cob leaf feeds showed no significant effect on digestibility.

The results concerning the rebinding of label, that was washed from an already labelled feed sample and then incubated *in vitro* with an unlabelled sample, showed that the originally unlabelled feed became labelled during *in vitro* incubation. A quantity of label which was similar to the amount that was bound to the originally labelled feed, was now also bound to the *in vitro* residues.

This is not a desirable situation since it shows that when soluble marker, (which was washed from a feed that was originally labelled but not washed) is put into contact with rumen digesta or other feedstuffs, it would bind to the new substrate with the same tenacity than to the original feed. Thus all the rumen digesta would become labelled from a feed that was labelled, but not washed, and put into the rumen.

With rate of passage studies done on sheep in this experiment, the soluble fraction of the labelled feed was not washed off. Thus the results concerning passage from the rumen could not be used. The results obtained in the lower gastro intestinal tract may be used, since in that area, there is no evidence of a differential flow for solids and liquids.

A method developed at the ADSRI (Pienaar & Roux, 1984b) was verified and used to study digesta flow kinetics in the hindgut. This method does not use the assumption of first order kinetics to calculate mean retention times. The results are independent of the shapes of the marker passage curves, but uses the assumption that flow is relatively constant over time. This situation was obtained by feeding the animals every 4 hours. When the method was verified it showed that the original results of Pienaar & Roux (1984b) were confirmed and the assumption of a relatively constant flow over time was true for the specific situation where animals were fed regularly.

The results obtained in the lower hindgut showed significant differences between diets in their mean retention times between the hindgut and faeces. These differences were caused by differences in rate of passage. The mean mass of non-fermentable OM in the hindgut did not differ significantly between diets. This indicates the possibility of a simplified approach to hindgut digestion kinetics when a constant digesta mass in the hindgut could be assumed.

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VS.3133/05/2/6: PROTEIN NUTRITION: PROTEIN TURNOVER IN MUSCLE TISSUE OF GROWING RATS.
1984-1988
F.K. Siebrits

Several studies have shown that protein deposition rate of pigs follows a curvilinear pattern where a peak deposition rate is reached with a subsequent decline. The aim of this study was to follow the changes in muscle protein synthesis and degradation during growth in order to study the mechanisms involved in developmental changes in the pattern of net protein deposition during growth.

An initial slaughter group of 10 rats was killed at 21 days of age and their body composition determined. Eleven groups of 6 rats were individually caged, kept at 20 °C with a 12 h light/dark cycle and fed *ad lib* on a standard laboratory diet. Muscle protein synthesis was determined at 25, 28, 30, 31, 32, 35, 40, 56, 65, 75 and 90 days of age using the so called flooding dose technique. Another 20 rats were kept concomitantly in order to measure changes in body composition between 21 and 90 days of age. Live mass and feed intake were recorded daily.

The mean live masses of 27 rats were plotted against age from 23 to 90 days of age. A "break" in the growth curve between 30 and 31 days of age was evident from the plot. A distinct deviation from the expected decay curve of fractional protein synthetic rate coincided with the "break" in the growth curve. The increase in net protein deposition rate between days 28 and 31 despite a decrease in fractional synthetic rate, was due to a proportionally greater decrease in breakdown rate. A strong negative relationship between synthesis rate and breakdown rate was found. The ratio of protein deposited to protein synthesised reach a maximum (0.957) when absolute synthesis rate and absolute degradation rate reached a minimum.

It was concluded that maximum efficiency did not coincide with maximum deposition and that maximum deposition did not necessarily imply maximum efficiency in terms of protein deposited per unit of protein synthesised. It implied that the energy cost of protein deposition increased with age if a constant requirement of 4 mol ATP per mol of peptide bond formation was assumed. A further implication is that, in animal production, it would be more advantageous to manipulate degradation than to manipulate synthesis in an attempt to stimulate protein deposition.

VS.3133 05 2 7: PROTEIN NUTRITION IN FARM ANIMALS: ESTIMATION OF PROTEIN DIGESTIBILITY
BY MEANS OF THE CHICKEN. 1985-1987
P.H. Henning

In 1980 the Agricultural Research Council (ARC) reviewed the nutrient requirements of ruminants and abandoned the previous system of assessing protein requirements based on digestible crude protein, in favour of a new approach involving rumen degradable protein and undegraded dietary protein (UDP). The UDP fraction is important in supplementing the amino acid nitrogen (N) of microbial origin so as to meet the needs of the tissues. Thus an easy and reliable method of evaluating digestibility of UDP would be of great benefit.

A bio-assay for the measurement of available amino acids in feedstuffs for poultry was reported by Sibbald. It involves force feeding of fasted adult cockerels with a known quantity of the test feedstuff and collection of the resulting excreta. Since the post-ruminal process of protein digestion in ruminants is assumed to be comparable to that occurring in the digestive tract of monogastric animals, the present study was carried out to determine whether Sibbald's method for measuring digestibility in chickens can be used to predict protein digestibility in the small intestine of sheep.

Five different diets were formulated to obtain some variation in the amount and digestibility of the resulting UDP fraction. Approximately 1 100 g of each diet was fed in six equal portions at 4 h intervals to

each of two randomly selected South African Mutton Merino wethers, fitted with cannulae in the abomasum and terminal ileum.

From day 9 of the 25-day experimental period, a solution of chromium (Cr) ethylenediaminetetracetic acid complex was mixed daily with the feed. From day 15 to 18, samples of abomasal and ileal digesta were collected from each sheep every 8 h, with a 10-h interval between days to allow a shift in sampling times. This sequence allowed samples to be obtained at every even hour of the 24-h day. The individual samples were composited to obtain an abomasal and ileal digesta sample for each sheep for calculation of digesta flow. Using the same procedure abomasal digesta was collected from each sheep from day 22 to 25.

Approximately 25 g of freeze dried abomasal digesta from each of the 10 multi cannulated sheep was fed to each of two adult Amberlink cockerels according to the method described by Sibbald. The excreta was subsequently collected for a period of 60 h. Four additional birds were treated similarly but received glucose instead of abomasal digesta to allow corrections to be made for metabolic and endogenous nitrogen losses.

The digestibility of the utilisable N fraction in the chicken was much lower ($P < 0.01$) and more variable than in the small intestine of sheep.

The relationship between true digestibility of utilisable N in the chicken and the sheep small intestine was determined. When the mean digestibility values for abomasal digesta from all 5 diets are included the regression is not significant ($P = 0.59$; $r = 0.33$). However, there appears to be some kind of relationship for all diets except diet D. Excluding diet D from the regression results in a significant ($P < 0.05$) correlation ($r = 0.98$) between digestibility of utilisable N in the chicken and in the sheep small intestine.

From these results it can be concluded that, although a close correlation between protein digestibility in the chicken and the sheep small intestine can be demonstrated, it did not hold true for all diets tested. Furthermore, digestibility in the chicken was significantly lower and much more variable than in the sheep small intestine. The use of the chicken, according to Sibbalds method, to predict protein digestibility in the small intestine of sheep can thus not be recommended unconditionally.

• Genetics

VS.3133/06/1/1: GENETIC DEFECTS IN FARM ANIMALS: GONADAL HYPOPLASIA IN CATTLE. 1983-1988
G.W. Kay

Although heritable gonadal hypoplasia in cattle has been described from a pathological point of view, little is known of the physiological processes responsible for the syndrome. This condition which occurs in the agriculturally important Nguni breed of cattle of South Africa, has a long-term detrimental effect on fertility and therefore has to be checked. Gonadal hypoplasia is peculiar in that firstly it commonly occurs unilaterally, and secondly, the left gonad is usually the affected organ.

The light of the inherent asymmetry of mammalian aorta and vena cava and of the subtly balanced blood supply required by the testis, the anatomy and physiology of the circulation of the hypoplastic testis was investigated.

The investigation is based on gross- and micro-anatomical studies supplemented by related physiological and experimental surgical studies. Dissection of the testicular artery and vein showed frequent deviation of the vascular pattern from the normal. The principal anatomical finding was a highly significant correlation between the diameter of the lumen of the testicular artery and the testicular mass. Blood flow studies further supported this finding, there being a highly significant correlation between total blood flow to the testis and testicular mass, this relationship extending from the small hypoplastic testis through to the large normal testis. Histological studies on the testis confirmed the previously documented relationship between testis mass and semi-niferous tubule diameter as well as the absence of spermatogenesis in hypoplastic testis. Hormonal and biochemical studies showed that the Leydig and Sertoli cells of hypoplastic testis were active in producing testosterone and androgen binding protein at levels comparable to that of normal testis. Surgical intervention to limit the growth of the testicular artery in young bulls led to a significantly reduced rate of growth of the testis which persisted over at least 10 months.

It is concluded that the recessive gene responsible for gonadal hypoplasia primarily affects the growth of the testicular artery and that due to the inherent limited ability of the testicular artery to dilate, the normal growth of the testis is retarded, resulting in deterioration of the germinal epithelium and hypoplasia of the testis.

VS.3133.06 1.2: GENETIC ASPECTS OF POLYMORPHISM IN FARM ANIMALS: MILK POLYMORPHISM.
1977-1987
E.H.H. Meyer

Milk samples were collected from ten *Bos indicus* Sanga breeds, three *Bos indicus* Zebu breeds and six *Bos*

taurus breeds. Results on the gene frequencies of the polymorphic milk proteins were investigated in 2 530 milk samples.

The α_{s1} -casein locus is polymorphic in all breeds, except the Dairy Shorthorn. The B allele has a higher frequency than the C allele in all breeds, with the exception of the Brahman. In the Malawi Zebu and Tuli the frequencies are identical. The higher B frequency is especially true for the *taurus* breeds studied, except for the Jersey. In Sanga breeds the C allele is quite high in the Tuli, Kavango, Ciskei, Caprivi, Afrikaner, Bonsmara and Shangana.

The highest degree of polymorphism was noted at the β -casein locus, with a total of four alleles being observed. The A_3 allele is extremely rare, occurring only at very low frequency in the Kavango, Lincoln Red Shorthorn and Friesian. The presence of the A_3 allele in the Kavango is unique, this being the first case found in Sanga cattle. A_1 and A_2 are present in all breeds at moderate frequencies. In the Sanga and especially the Zebu breeds the A_2 allele is more abundant than A_1 . The β -cn B is a unique genetic marker being present at relatively low frequencies in all *taurus* (except the Beef Shorthorn) and Zebu breeds. It is absent in the Sanga breeds, the exceptions being the Bonsmara, Drakensberger and Tuli. In the latter three breeds an infusion from *taurus* breeds can be postulated. Therefore, the β -cn B variant can be regarded as a critical genetic marker, differentiating between pure Sanga breeds and Zebu or *taurus* breeds.

The A and B alleles of κ -casein are present in all breeds. Usually, the frequency of the A allele is higher than B, except in the case of the Afrikaner, Nguni, Pedi and especially the Jersey with an extremely low frequency of 0,006.

In the case of the whey proteins, the α -lactalbumin is monomorphic for the B variant in the *taurus* breeds, which is in agreement with results from European studies. It is also monomorphic in certain Sanga breeds with a low number of samples analysed, like the Caprivi, Ciskei, Kavango and Tuli. This qualification does not hold for the Drakensberger, which is monomorphic despite more than 100 samples having been investigated. The frequency of the A variant is generally low, with the highest value in the Brahman (0,360).

The second whey protein, β -lactoglobulin, is polymorphic in all the breeds studied so far. The frequency of the A allele is lower than B in all breeds and especially so in the case of the Sanga breeds. A third allele, β -lg C, has been observed only in the Malawi Zebu; the frequency also being rather low.

In conclusion, therefore, two rare variants have been found amongst the polymorphic milk proteins studied in Southern African cattle breeds, viz β -casein A_3 and B-lactoglobulin C. Furthermore, the absence of the β -casein B allele can be regarded as typical for the African Sanga breeds.

VS.3133/06/1/3:

GENETIC ASPECTS OF HAEMOGLOBINS IN FARM ANIMALS: CATTLE. 1977-1987
E.H.H. Meyer

A total of 13 780 samples from 31 cattle breeds were analysed. The gene frequencies of the four different haemoglobin (Nb) alleles are given in Table 1.

The HbI allele is present in all Sanga breeds investigated. The frequency ranges from 0,052 in the Nguni and Pedi to 0,163 in the Kavango. The frequencies in the Vambo, Shangana and Afrikaner are also relatively high. An exceptionally high frequency was observed in the Malawi Zebu (0,236), which might indicate a major contribution by local Sanga cattle to the formation of the Malawi Zebu. The HbI allele is also present in three non-Sanga breeds; viz. the Santa Gertrudis, Pinzgauer and Simmentaler. The very low frequency and the known use of upgrading mainly from Afrikaner cows indicates the probable origin by infusion from Sanga breeds. This must be taken into account with parentage determinations and in discussions on breed purity.

The HbC allele occurs only in the Brahman and at very low frequency (0,002). Although the Santa Gertrudis has the Brahman as one of its parental breeds, no animals with HbC were observed.

With very few exceptions (Brahman and Jersey), the HbA allele has the highest frequency in all breeds studied. In the case of some north European breeds, like the Angus, Ayrshire, Dexter, Friesian, Hereford, Shorthorn and Sussex the HbA allele has been fixed. This finding is in agreement with overseas results and is a useful genetic marker for breed purity.

The HdB allele is present in all the Sanga and Zebu breeds, as well as a number of European breeds. Except for the Brahman and Jersey, the frequency is rather low, sometimes even lower than the HbI.

In summary, therefore, the HbI variant is one of a number of unique genetic markers suitable for a taxonomic classification of domestic cattle as indicated in Table 2. In the case of the indigenous *Bos indicus* Sanga breeds we have a submetacentric Y chromosome, the presence of haemoglobin I and α -lactalbumin A, while albumin C, haemoglobin C and β -casein B are absent.

TABLE 1 Gene frequencies of haemoglobin alleles in Southern African cattle breeds

Breed	Number	Haemoglobin allele				Breed	Number	Haemoglobin allele			
		A	B	C	I			A	B	C	I
Afrikaner	1538	0,678	0,198	-	0,124	Pinzgauer	182	0,973	0,022	-	0,005
Bonsmara	1923	0,863	0,044	-	0,093	Simmentaler	955	0,834	0,163	-	0,003
Drakensberger	1351	0,907	0,025	-	0,067	Brown Swiss	99	0,919	0,081	-	-
Caprivi	122	0,832	0,094	-	0,074	Charolais	126	0,909	0,091	-	-
Ciskei	39	0,846	0,128	-	0,026	Devon	180	0,872	0,128	-	-
Kavango	95	0,768	0,068	-	0,163	Gelbvieh	9	0,944	0,056	-	-
Nguni	230	0,750	0,198	-	0,052	Guernsey	202	0,765	0,235	-	-
Pedi	48	0,740	0,208	-	0,052	Jersey	471	0,493	0,507	-	-
Shangana	88	0,756	0,114	-	0,131	Limousin	21	0,929	0,071	-	-
Vambo	268	0,733	0,131	-	0,136	Angus	465	1,000	-	-	-
Tuli	100	0,670	0,300	-	0,030	Ayrshire	105	1,000	-	-	-
Mashona	100	0,800	0,100	-	0,100	Dexter	52	1,000	-	-	-
Malawi Zebu	55	0,500	0,264	-	0,236	Friesian	1192	1,000	-	-	-
Santa Gertrudis	620	0,961	0,037	-	0,002	Hereford	988	1,000	-	-	-
Brahman	1021	0,463	0,534	0,002	-	Shorthorn	635	1,000	-	-	-
						Sussex	501	1,000	-	-	-

TABLE 2 Unique genetic markers for taxonomic classification of domestic cattle (genus: *Bos*; family: Bovidae)

Genetic markers	<i>Bos taurus</i>	<i>Bos indicus</i> (Sanga)	<i>Bos indicus</i> (Zebu)
Alb C	-	-	+
Hb C	-	-	+
Hb I	-	+	-
β - Cn B	+	-	+
α - Lac A	-	+	+
Y Chromosome			
Submetacentric	+	+	-
Acrocentric	-	-	+

VS.3133/06/1/7: BREEDING OF LABORATORY ANIMALS FOR GENETIC STUDIES. 1977-1987
E.H.H. Meyer

Techniques were developed and applied for the breeding, maintenance and management of laboratory animals in the newly founded Small Animal Unit. This also included strict hygiene and disease control for the unit to be operated under SPF-conditions (specific pathogen free). Regular microbiological monitoring indicated a minimum of infections. *Pasteurella pneumotropica*, *P. aerogenosa*, *Streptococcus*, *Enterobacter* and *Klebsiella* species were encountered at some stage. Different treatments were used successfully, e.g. antibiotics in the drinking water. Therefore, an acceptable and defined health status of breeding colonies and experimental animals could be maintained.

The following recognised and experimental lines were maintained for different periods of time: outbred Wistar rats; inbred rat lines produced from the Wistar colony; outbred HA/Icr mice; inbred BALB/c mice; random-bred colony of (BALB/c x HA/Icr) x HA/Icr for the production of nude mice; hairless mutant line of mice obtained from a mutation in the Onderstepoort random-bred albino stock. Approximately 11 000 mice and 7 000 rats were produced for experimentation and maintenance of lines.

Inbred lines are derived by at least 20 generations of brother x sister matings. The main problems in maintaining this genetic status arise because of factors like selection, mutation, migration and genetic drift. This leads to divergence of sublines maintained in different laboratories. Therefore, the genetic status of inbred lines should be monitored periodically. The available genetic markers include observable traits like pigmentation morphometric traits (e.g. measurement of mandibles), electrophoretic and immunogenetic markers. An application of mandible measurements was tested on rat lines selected for growth rate and efficiency of feed conversion in comparison with the outbred Wistar control population, by means of a

discriminant function analysis. The control population showed a more symmetrical and a wider distribution, whereas the selected lines had a smaller distribution.

In addition to laboratory rats and mice, a colony of the wild pouched mouse, *Saccostomus campestris*, was started for comparative purposes. The development and behaviour of the wild species was studied *inter alia* as an indicator for optimal conditions of intensification for the breeding and maintenance of laboratory animals, whereas basic data on its development and reproduction were also obtained.

VS.3133/06/1/13:

GENETIC STUDIES ON FARM ANIMALS: DEVELOPMENT OF BIOCHEMICAL
METHODOLOGY FOR ANTIGEN CHARACTERISATION WITH REGARD TO GENETIC
ASPECTS OF DISEASE AND PARASITE TOLERANCE. 1985-1986

M.C. Field

Hepatitis B represents a major public health problem of worldwide concern. The development of chronic forms and the association between HBV and hepatocellular carcinoma imply the need for an efficient and safe vaccine. Several laboratories have developed plasma-derived vaccines composed of defective 22nm HBsAg viral particles of which one has been licensed.

Immunity against HBV is elicited by antigenic determinants exposed on the virus envelope. The translational products of the envelope gene comprise three related proteins differing in size, all of which are present on the HBV envelope:

- (a) a 226-amino acid protein identified as the major constituent of the HBV envelope and HBsAg, termed the S-protein;
- (b) a protein with 55 additional amino acids at the amino-terminal, coded by the Pre-S₂ region of the envelope gene upstream of the S-region, named the "middle" protein, and
- (c) a 389- or 400-amino acid protein coded for by the entire envelope gene (Pre-S + S) and termed the "large" protein.

Literature report vary concerning amino acid and polypeptide compositions of HBsAg and thus warrant a characterisation of HBsAg, especially concerning the presence of the Pre-S and S gene products. Another objective was to gain information about the conformation of the antigen proteins by predictive and experimental methods. This was necessary for a better understanding of the immunochemical properties of the proteins present in the HBsAg preparation.

HBsAg preparations used contained, apart from the major S-protein, other proteins derived from the Pre-S region of HBV-DNA. This was indicated by amino acid analyses which were in agreement with an amino acid composition of the middle and large proteins. SDS-PAGE and gel permeation chromatography of reduced, alkylated and CNBr-treated HBsAg revealed components compatible in size to proteins coded for by the (Pre-S₂ + S) and (Pre-S₁ + S) regions.

Secondary structure profiles of the different gene products predicted that the Pre-S region has some alpha-helix forming potential, while the S-gene product consists mainly of beta-sheets and some beta-turns, apart from aperiodic structure.

CD spectroscopy confirmed the low helix content of HBsAg and indicated that neither urea or SDS had a noticeable influence on the gross conformation of HBsAg. CD and fluorometric studies with ANS showed that this probe for hydrophobic interactions bound non-specifically to HBsAg.

Hydrophilicity and segmental flexibility profiles predicted possible antigenic determinants which should be important in the synthesis of peptides which could be potentially useful in synthetic vaccines against HBV infection.

An ELISA assay recognised a conformation-dependent antigen in the HBsAg preparation. SDS lowered the affinity of HBsAg for polyclonal anti-HBs, even though its effect on the overall conformation was small.

• Upgrading

VS.3133/07/1/4:

UPGRADING STUDIES ON ANIMALS: EVALUATION OF THE INFLUENCE OF THE
IMPORTATION OF GERM PLASM ON STUD-CATTLE BREEDING. 1985-1988

H.E. Theron

The quantitative aspects of semen importations of 4 South African dairy breeds and 10 beef breeds between 1974 and 1986 were studied. The applications for permits to import semen were used, as the actual importations were not available for the initial period. Since 1980 the actual number of units imported were also available and the percentage successful importations could thus be determined.

Dairy cattle

Applications for 125 854 units of Friesian semen (of which 89 % were successful), 33 206 units of Ayrshire semen (of which 83 % were successful), 24 827 units of Jerseysemen (of which 88 % were successful) and 9 117 units of Guernsey semen (of which 79 % were successful) were received between 1974 and 1986.

Friesian semen importations showed a steady growth until 1984, which it declined slightly. None of the importations in the other breeds showed a definite pattern. Certain Friesian bloodlines are favoured by South African breeders. The Ivanhoe (Osborndale Ivanhoe) and Chief (Pawnee Farm Arlinda Chief) lines were the most popular, in fact, 52 % of the units applied for were for semen from these bulls or their male progeny. Round Oak Rag Apple Elevation, a grandson of Osborndale Ivanhoe, also formed an important popular bloodline. The other breeds favoured certain popular bulls rather than bloodlines, except the Jersey breed, where the generator (Milestone Generator) bloodline was important.

It was calculated from the registered progeny of 15 popular Friesian bulls that 6 units of semen were imported for each heifer registered. The ratio of males to females registered was about 1:3. Guernsey breeders imported 10,3 units of semen from 7 popular bulls for each registered heifer. The ratio of male to female calves registered here was about 2:3.

Although only 25-30 % of dairy cattle in South Africa are bred using AI (Hofmeyr, 1985), bulls that were bred from imported semen, dominate the local AI-market and stud sales. A small amount of semen is thus imported from a few genetic sources, and used extensively to breed bulls for local use (AI and natural serving bulls), especially in the case of the Friesian breed. This could narrow the genetic base of the breed. The popular American bloodlines have influenced the local breed positively by improving the breed, but could also have a negative influence by narrowing the genetic base, as well as eliminating animals adapted to local conditions through years of selection.

Beef cattle

The ratio of semen doses importations applied for per number of registered females in each breed, was calculated and from this ratio it was deducted that the Charolais, Aberdeen Angus and Brangus breeders imported proportionally more semen than other breeds. They imported sufficient semen to inseminate 10 to 14 % of the registered cows, in comparison to less than 5 % in the other breeds. In most of the breeds between 20 and 40 % of the semen used on registered cows is imported. In the case of the Brahman 8 units of semen is required for every calf registered.

Breeders of some breeds tend to concentrate on the importation of semen from one or only a few bulls, i.e. 38 % of the South Devon semen is from one bull, and 46 % of the Brangus semen is from 2 bulls. The larger breeds such as the Aberdeen Angus, Brahman, Hereford and Simmentaler on the other hand, do not concentrate on a few popular bulls, but tend to import semen from a variety of bulls. The effect of semen importations seems to be smaller on the beef breeds than it is on the dairy breeds.

VETERINARY RESEARCH

Entomological investigations

EXTERNAL PARASITES

• Pests

OP.3261/20/1/4:

RESISTANCE OF TICKS TO ACARICIDES. 1976-1988
A.M. Spickett

Resistance of ticks to acaricides has been a problem in South Africa since the one-host blue tick, *Boophilus decoloratus*, was shown to be resistant to arsenic in 1959. The advent of the organo-phosphate acaricides in the early 1970's provided producers with a wide choice of acaricides and this project was registered to monitor the resistance situation and provide an advice service on acaricide usage.

During the active monitoring period (1976-1979) Republic-wide tests for acaricide resistance in tick populations showed the fairly rapid spread of resistance to organophosphates in both one-host and multi-host ticks. Data could be extrapolated on cross resistance within the organophosphate group and advice to producers was on an established scientific basis.

With the advent of the highly effective pyrethroid acaricides in the late 1970's the situation changed somewhat and the project concentrated mainly on the establishment of pyrethroid resistance and its cross reaction with organophosphate resistance in the laboratory.

Attention was also given to laboratory test efficacy in portraying field resistance. First indications of laboratory resistance to pyrethroid resistance were realised in 1984 and subsequently the Coopers (Kwanyanga) Research Team have reported extensive field resistance by the one-host *Boophilus* in 1987.

Tick resistance to acaricides is genetically based and, as such will be a continual potential with any chemical developed for tick control. The rate of development of resistance is related to the frequency of application which is extremely variable in South Africa, resulting in an almost random establishment of resistance. This makes advice to producers on the use of specific acaricides extremely difficult especially when incorrect usage of acaricides (70 % of cases) is also considered. Producers in any case tend to change their acaricide at the first sign of inefficacy which occurs some 3 months before test results can confirm resistance or incorrect usage.

This project has also yielded data on the prevalence and distribution of tick populations resistance to organophosphates; supported an M.(Vet. Med.) thesis on the evaluation of in vitro test methods for acaricide resistance in *Boophilus microplus*; provided data as to acaricide test efficacy; gave the first glimmer of laboratory pyrethroid resistance and served as a sounding board for dose/mortality statistical tests.

Recent staff changes and project priority ratings have reduced this project to that of breeding certain tick strains with no continuation in the scientific trials performed on them. As such the project is no longer viable.

Bacterial investigations

BACTERIA

- Pathology

OP.32/01/19/2/7:

THE IMPROVEMENT OF THE *CAMPYLOBACTER FETUS* VACCINE. 1984-1988
M.L. van der Walt

Two aims were proposed to improve the composition of the *C. fetus* vaccine. A liquid medium was to be found which would yield enough cells of *C. fetus* spp. *venerealis* for the inclusion of this strain in the vaccine. The other objective was to determine whether the *C. fetus* spp. *venerealis* strain to be included in the vaccine, did contain a microcapsule, the structure which elicits immunity in the animal.

A number of liquid cultivation media were examined and the medium described by Dennis & Jones (1959) was found to support the growth of *C. fetus* spp. *venerealis* the best. The medium presently used for the growth of the *C. fetus* strains included in the vaccine, did not yield adequate growth of *C. fetus* spp. *venerealis*.

With the use of serum agglutination tests it was shown that the *C. fetus* spp. *venerealis* strain to be included in the vaccine, did not contain a microcapsule. Other *C. fetus* spp. *venerealis* strains did contain this structure and should be considered instead as vaccine strains.

Molecular biological investigations

MACRO-MOLECULES

- Virology

OP.32/21/12/1/3:

MACRO-MOLECULAR/SEROLOGICAL STUDIES OF JAAGSIEKTE. 1982-1987
M.S. Myer

Jaagsiekte, or ovine pulmonary adenomatosis is thought to be caused by a retrovirus that specifically transforms surfactant-producing alveolar epithelial cells. Concomitant with this transformation is an overall increase in the alveolar macrophage (AM) population. The purpose of this study was to determine if there is any causal relationship between the transformed epithelial cells and the macrophages, and whether the latter influence tumour cell growth.

The increase of AMs in jaagsiekte sheep lungs is not caused by excessive surfactant production but is due to a chemotactic factor secreted by the tumour cells. This factor has a molecular mass in the region of 13 kilodaltons (kDa), is stable at 56 °C but labile at 100 °C, and being sensitive to proteases, indicates that it is a small protein molecule.

Both growth inhibitory and growth stimulatory factors were detected in vitro in medium from cultures of lung lavage cells exposed to jaagsiekte tumour cell supernatant. The macrophage component of the lavage cells was found to produce a growth stimulatory factor that was replaced by a growth inhibitory factor following exposure to jaagsiekte tumour cell supernatant. Whether these factors stimulated or inhibited DNA synthesis depended to some extent on whether the indicator cells were transformed or not.

The inhibitory factor had a molecular mass between 0,3 and 10 kDa and was inactivated by heating at 62 °C or by trypsin. In contrast, the predominantly stimulatory factors consisted of larger polypeptides, in the 13-25 kDa range, which was stable at 62 °C but inactivated at 100 °C.

AMs infected with lentivirus were found to be chemotactically inhibited as well as having a reduced leukokine production potential. Peripheral blood monocytes isolated from sheep suffering with acute jaagsiekte were depressed with regard to their DNA synthesis potential.

• Protozoology

OP.32/21/13/1/2:

THE ISOLATION OF DNA AND THE CONSTRUCTION AND PARTIAL
CHARACTERISATION OF A GENOMIC LIBRARY OF *COWDRIA RUMINANTIIUM*.
1987-1989

R.E. Ambrosio

Cowdriosis or heartwater is a tick-borne disease of cattle and sheep which occurs in Africa and the Caribbean and which causes large stock losses annually. This disease is caused by a Rickettsia-like parasite, *Cowdria ruminantium*. Presently there are no methods available for the rapid and accurate diagnosis of heartwater suitable for routine use in large herds. The development of rapid and reliable diagnostic procedures has become possible in recent years through recombinant DNA technology. This has resulted in a programme to develop nucleic acid probes for *C. ruminantium* as well as to eventually develop a sub-unit vaccine against this parasite.

Initially, two genomic libraries of *C. Ruminantium* Welgevonden and Kwanyanga isolates were constructed in the bacteriophage expression vector, λ gt 11. These libraries were constructed by digesting the *Cowdria* DNA with the restriction endonuclease *Eco*R1, followed by cloning the digested DNA into the vector. The DNA was in vitro packaged and the libraries stored at 4 °C. These libraries contained a percentage of bovine and sheep DNA owing to problems experienced in removing this DNA from the *Cowdria*-infected blood. After using a method which removed most of the host cell nucleic acids from a *Cowdria*-infected bovine endothelial cell line, a third genomic library was constructed of the Welgevonden isolate in the λ gt11 vector. This library has been screened by nucleic acid hybridisation, as well as by immune-blotting. In both cases positive clones have been obtained.

AGRICULTURAL RESOURCE UTILISATION RESEARCH

RESOURCE RESEARCH

Primary resources

SOIL

• *Soil science*

GB.5111/32/6/2:

A PEDOLOGICAL INVESTIGATION INTO SOILS ASSOCIATED WITH ROCKS OF THE VENTERSDORP SUPERGROUP IN THE WESTERN TRANSVAAL. 1987-1989

J.N.J. Viljoen

Outcrops and sub-outcrops of the rocks of the Ventersdorp supergroup occur extensively over the western portion of the Highveld Region in the Western Transvaal. The dominant rock type is andesitic lava, with sedimentary rocks also present.

The main objective of this study was to collect information pertaining to soils overlying the rocks of the Ventersdorp supergroup and an evaluation of the influence of these rocks on soil formation. To reach this objective different types of soil occurring on these rocks were differentiated on the basis of morphology and mineralogy.

The area studied was divided into six sub-areas, and one or two sample areas were allocated to each of these sub-areas. In each sample area the soil was studied in catenary sequence. Profile pits were described and samples taken for physical and chemical analyses. The sand fraction was separated into light and heavy mineral fractions. Standard procedures were used for the heavy mineral analyses. The surfaces of quartz grains were studied with a petro-graphic microscope and with the aid of an electron microscope. X-ray diffraction was used to determine the mineralogy of the silt and light mineral fractions and a number of selected clay samples.

One or more of the following characteristics, which relate to the underlying andesitic lava were observed in the soil which occur on these rock types, despite the universal presence of wind transported material. These were epidote, angular quartz grains with undulatory extinction as well as a high percentage silt, coarse and medium sand and fragments of amygdaloids. Aeolian sand in variable amounts is present in all the profiles, and is an important factor affecting the genesis of the soil.

Aeolian sand of different ages was possibly distributed and deposited during dry phases in the Quaternary. The influence of aeolian sand on soil formation was evaluated on the basis of mineralogy, grain size distribution, surface characteristics and undulatory extinction of quartz grains as well as soil morphology.

The weathering products of different origin were subsequently mixed in situ by bioturbation. The present soil mantle of the study area is a product of a number of processes associated with climatic changes in the past, the present climate and mixtures of parent materials of different origin.

A comparatively small number of polypedons occur repeatedly in the study area. The relative occurrence of each differs considerably from sub-area to sub-area because of the differences in geomorphological history between sub-areas.

Each polypedon, as described, possesses its own agricultural value. Within the relevant climatic zone this is determined mainly by water retention and internal drainage. To quantify the latter, further experimental work is needed which includes in situ soil and water measurements with various crops.

V.5111/32/1/1:

SOIL: THE AVAILABILITY OF POTASSIUM IN A MANGANO SOIL SERIES TO LUCERNE UNDER IRRIGATION AT SANDVET. 1978-1990

P.J. Snyman

In the Orange Free State Region there are widely differing opinions as far as K fertilisation is concerned. It is generally accepted that on most soils no increase in yield with K fertilisation is obtained. With the

supposition that continuous cropping places a great demand on the potassium supplying power of the soil. the maintenance of adequate levels of available K, without K fertilisation, could become a problem in the long run.

Results of a field trial on a Mangano soil of the Sandvet Irrigation Scheme for three seasons between 1980 and 1983 were used to determine the effects of K fertilisation on the changes in plant available K of the soil, yield of lucerne and K removal by the crop. K rates of 0, 150, 300 and 450 kg K ha⁻¹ were applied annually in a randomised block design with five replicates.

Lucerne yields were unaffected by rate of K fertilisation. Yields of untreated plots throughout the experimental period were higher than those of K-fertilised plots. The K concentration of plant samples was significantly higher on the K-fertilised plots only during the second and third seasons.

The available K content of the 0-150 mm soil layer decreased both with and without added K. Over the period of three years of continuous cropping it decreased from 181 to 75 mg K kg⁻¹ in the zero K treatment and to 123 mg K kg⁻¹ soil for the application rate of 450 kg K ha⁻¹. Assuming an average soil density of 1 500 kg m⁻³ the decrease in available soil K over a depth of 600 mm constitutes approximately 1 050 kg K for the zero K application and 620 kg for the 450 kg application rate. For the same treatments the K removal amounted to approximately 1 920 kg and 1 935 kg, respectively. The release of non-exchangeable K in the zero treatment, therefore, amounts to approximately 860 kg ha⁻¹. In the 450 kg K treatment K removal is equal to the total amount of applied fertiliser plus 585 kg available soil K, which approximates the depletion in available soil K.

V.5111/32/1/5:

SOIL: A COMPARISON OF DIFFERENT NITROGEN SOURCES FOR WHEAT ON A HUTTON SOIL AT VAALHARTS. 1983-1987

P.J. Snyman

The study was undertaken firstly, to test the relative efficiency of ammonium sulphate (21 % N), limestone ammonium nitrate (28 % N) and urea (46 % N) to supply wheat with nitrogen and, secondly, to investigate the mobility of NH⁺-N and NO⁻-N under irrigation. Results of a field trial on a Hutton soil (red apedal), with 8,4% clay in the B21 horizon, of the Vaalharts Irrigation Scheme for three seasons were used. A nitrogen rate of 140 kg N ha⁻¹ was applied in a randomised block design with six replications.

Measured in terms of grain yield there were no significant differences between the three nitrogen sources. The average yields for the three seasons were 4 913, 5 170 and 4 908 kg ha⁻¹ for ammonium sulphate, limestone ammonium nitrate and urea, respectively. At a yield of 5 000 kg wheat ha⁻¹ 119 kg N ha⁻¹ was removed by the grain. This is in agreement with the nitrogen fertiliser recommendations which are presently being used in the Free State Region. The N concentrations of the plants at growth stage 10 and 15 were not influenced significantly by the three nitrogen sources. The average N concentrations for ammonium sulphate, limestone ammonium nitrate and urea were 2,94, 2,85 and 2,95 % for growth stage 15.

For the different treatments the distribution of ammonium N and nitrate N were virtually identical in the 400-600 mm soil layer after the last irrigation. The NH⁺-N distribution was 4,8, 5,1, 7,0 and 6,6 mg NH⁺kg⁻¹ soil for the zero, ammonium sulphate, limestone ammonium nitrate and urea treatment, and 4,6, 4,6, 5,0 and 4,9 mg NO⁻ kg⁻¹ soil, respectively. It can be said that nitrogen leaching losses do not occur in the soil, with less than 10 % clay in the B21 horizon, under these specific experimental conditions. An application of 50 mm of water was given per irrigation.

CLIMATE

• Meteorology

GB.5113/33/1/8:

CLIMATE: WIND SURVEYS IN CITRUS PRODUCTION AREAS. 1978-1987

C.P. Welgemoed

The objective of the research was to gather sufficient wind data to determine long-term prevailing wind directions and speed in principal production areas of citrus in the RSA. The predominant directions of prevailing winds during the most susceptible growth period of the citrus fruit, enables the farmer to correctly plant the orientation of wind protection around orchards.

Wind data were gathered in the main citrus production areas. More than 60 stations were situated in the Eastern Transvaal Lowveld, Northern Transvaal, Western Transvaal and the valleys of the Gamtoos, Sundays and Hex Rivers. The data was processed by hand and long-term frequency distributions determined on a mainframe-computer. Wind roses were drawn on a micro-computer and plotter. Twelve roses (one per month) were drawn for each wind station, using the following wind speed increments:

5 - 14 km h⁻¹
 15 - 24 km h⁻¹
 25 - 34 km h⁻¹
 35 - 44 km h⁻¹
 44 km h⁻¹

One rose for a summer month (January) and another for a winter month (June) for five wind stations (Addo, Citrusdal, Nelspruit, Messina and Rustenburg) showed the difference in wind speeds between the main citrus production areas in the Cape Province and those in the Transvaal. Wind speeds were generally much lower for Transvaal stations. The use of wind protection is, therefore, of far greater importance in the Cape Province.

With the minimum speed at which significant damage occurs being considered at 15 km h⁻¹ (Green, Bozalek & Schoeman, 1975), and using wind roses as reference, wind directions observed most regularly during the period August till February were tabulated representing those directions that should be protected against wind.

RESOURCE UTILISATION RESEARCH (CROPS)

Field crops

SMALL GRAIN

• Crop science

H.5212/30/1/1:

SMALL GRAIN: VERIFICATION OF PRODUCTION TECHNIQUES AND YIELD NORMS FOR WHEAT ON AN AVALON SOIL FORM IN RHF 6043 IN THE HIGHVELD REGION. 1985-1987

G.G.J. Oosthuizen

With the establishment of guidelines for wheat cultivation in a specific resource situation, the regional development committee of the Highveld Region endeavoured to integrate all the detached information into an acceptable production process with an accompanying yield norm. It is, however, necessary that these guidelines be evaluated regarding the local practices in the relevant situation in order to identify problems and bottlenecks to the research worker as well as to serve as a demonstration of the recommended production techniques.

Factors included in the investigation were: ploughing and mulching; no fertilisers, recommended fertilisation, recommended fertilisation plus an additional 50% or 100%; sowing densities of 10 kg and 20 kg seed per hectare and three cultivars. The trial was planted annually on three planting dates (May, June and July), for three years in succession.

The final results of the trial are mostly in agreement with the recommendations of the Regional Development Committee of the Highveld Region.

During the drier seasons (1985 and 1987) mulching had the highest yield, whereas ploughing did better during 1986 which had an above average rainfall. Yield increased with an increase in fertilisers, but it was not economically justifiable. During the drier seasons the lower sowing density fared better than the higher density. Differences in yield of the cultivars were not significant and the recommendations of the Small Grain Centre can therefore be accepted with confidence. The June planting date had the highest yield whereas the July planting date yielded the lowest. Fertilisation and cultivation had no significant difference on grain protein content. During 1986 the grain protein content of the July planting was, however, higher than that of the May and June plantings.

• Nutrition

H.5213/05 1, 1:

THE GROWTH AND YIELD OF SOYBEANS ON A BAINSVLEI SOIL FORM IN RHF 6018 IN THE HIGHVELD REGION AS INFLUENCED BY DIFFERENT PHOSPHATE LEVELS.
1983-1988

P.J. Laubscher

The first aim of this study was to monitor plant development and nutritional uptake of soybeans in a pot experiment, at five different phosphorus levels by means of a growth study. The same experiment was repeated during the second season in a field experiment, to compare the results with conditions similar to that of the soybean producer. Phosphorus levels of 0; 20; 40; 80- and 160 mg kg⁻¹ were used. Optimum moisture was assured during the pot experiment, whereas additional irrigation was given to the field experiment.

The second aim was to find the optimum phosphorus level of soybeans grown on a Bainsvlei soil in the Highveld Region. This was achieved by repeating the field experiment for a further three years without the growth analysis. In the last part of the study, time of development, plant height and leaf analysis were monitored at the flowering and full-pod growth stages. Final seed mass was also determined.

Analysis of the soil phosphorus was done annually after harvest. Each year superphosphate was applied in order to bring the soil phosphorus to the desirable levels.

In the growth analysis an increase in the soil phosphorus levels caused a significant increase in the dry mass of the whole plants, leaves, stems, roots and pods. The relative growth rates also increased during early vegetative growth. The leaf area index and stem dry mass:total plant dry mass ratio increased with the increase of phosphorus fertilisation. Leaf mass:total plant mass ratio increased during early growth, whereas the root mass:total plant mass ratio decreased during the growth season.

The dris indices of the pot experiment showed that phosphorus was not the most limiting element in the soybean leaves with 80 mg P kg⁻¹ or a higher treatment. Dris indices in the first year of the field experiment indicated that phosphorus was the most limiting element in the leaves, probably because of a poorer uptake compared to that of the pot experiment.

On the whole, in this study, fertilisation did not significantly change the time of development from plant to the flowering or full-pod growth stages. Plant mass was increased at the flowering stage. Phosphorus uptake was increased at both the flowering and full-pod growth stages. A critical phosphorus level in the leaves (at 95 % relative yield) of 0,32 % was found at the flowering stage. Phosphorus uptake tended to increase the percentage of nitrogen, potassium and calcium in the leaves.

From this study, the optimum relative yield between 100 and 104 % was obtained between soil phosphorus levels of 23 and 31 mg kg⁻¹P.

RESOURCE UTILISATION RESEARCH (ANIMALS)

Ruminants

LARGE STOCK

• Reproduction

N.5311 04 1, 1:

PRODUCTION AND REPRODUCTION IN BEEF CATTLE: RELATIONSHIP BETWEEN DIFFERENT PLANES OF NUTRITION *PRE-PARTUM* AND TARGET MASS AT THE START OF THE MATING SEASON ON THE REPRODUCTIVE PERFORMANCE OF THE BEEF COW. 1978-1988

J.H. Meaker

Records on body mass and reproductive performance of 920 Sussex type cows, ranging in age from yearlings to adults (5 years and older) were examined for relationships between body mass (X) and conception (Y).

percentage gain or loss over the winter. The following significant relationships were recorded between body mass at the start and end of the mating season and conception:

Age and number of times mated	Relationship at start and end of mating season			r
1 year - mated 1st time	Start Y	=	-16,29 + 0,28X	0,6930
	End Y	=	-354,56 + 2,61X - 0,004X ²	0,9652
2 years - mated 1st time	Start		no significant relationship	
	End		no significant relationship	
2 years - mated 2nd time	Start Y	=	-51,97 + 0,37X	0,8892
	End		no significant relationship	
3 years - mated 2nd time	Start Y	=	30,86 + 0,16X	0,8722
	End		no significant relationship	
3 years - mated 3rd time	Start Y	=	42,55 + 0,12X	0,9912
	End		no significant relationship	
4 years - irrespective of matings	Start Y	=	-1 060,98 + 5,05X - 0,006X ²	0,8992
	End Y	=	-1 103,04 + 5,07X - 0,005X ²	0,8912
Adult cows - irrespective of matings	Start Y	=	-415,58 + 1,94X - 0,002X ²	0,9483
	End Y	=	-630,77 + 2,70X - 0,003X ²	0,9838

No relationship could be established between conception rate and mean body mass at the start of the winter, end of the winter, percentage gain or loss over the winter and percentage gain over the breeding season.

From the results of this investigation it is evident that the mass of beef cows at the start of the mating season exerts a vital influence on subsequent conception rates. Mass changes prior to and during the breeding season exerted little influence on reproductive performance under the conditions of this study.

• Nutrition

H.5311/05/2/3:

LARGE STOCK: THE FERMENTATION CHARACTERISTICS AND CHEMICAL COMPOSITION OF MAIZE, GRAIN SORGHUM, FORAGE SORGHUM AND SUNFLOWER SILAGES, ENSILED WITH OR WITHOUT LACTIC ACID-PRODUCING BACTERIA.
1986-1988

C.H.M. de Brouwer

Investigations into the fermentation characteristics and chemical composition of maize, grain sorghum, forage sorghum and sunflower silages, as influenced by a lactic acid-producing bacterial inoculant, were performed.

Sunflower plants, harvested at the milky stage of maturity of the seed, resulted in a silage containing only 13,54 % dry matter (DM). The other silages contained approximately 30 % DM.

Maize and sunflower silages had an in vitro dry matter digestibility (IVDMD) of approximately 70 %, but grain sorghum and forage sorghum silages had lower IVDMD of approximately 60 and 53 % respectively.

Sunflower silage had the highest crude protein (CP) values (13,55 %), and forage sorghum silage the lowest (7,26 %). The CP content of maize and grain sorghum silage was 8,23 % and 9,42 %, respectively. Grain sorghum silage had the highest content of non-protein nitrogen as percentage of total nitrogen (NPN) (56,16 %) and forage sorghum silage the lowest (49,20 %), whereas intermediate values were obtained for maize and sunflower silage, viz 52,72 % and 51,01 %, respectively. Forage sorghum silage contained 16,61 % acid detergent fibre-nitrogen (ADF-N) as percentage of total nitrogen, which was high compared to the other crops (±10 %). The acid detergent fibre (ADF) content was found to be high in both forage sorghum and sunflower plants (38,02 and 37,13 %, respectively) compared to maize and grain sorghum plants (31,05 and 33,40 %, respectively). The ADF content of sunflower silage was approximately two percentage units lower than that of the sunflower plants.

Grain sorghum and forage sorghum plants contained 6,35 % water soluble carbohydrates (WSC) which can be regarded as low for satisfactory fermentation. Despite the low WSC content in these crops, fermentation was acceptable with final pH values of 4,15 and 4,24, respectively.

Sunflower silage produced much higher levels of all the fatty acids determined, when compared to the other crops. Ammonia-nitrogen content was also highest in this silage.

Inoculant treatment had little effect on the chemical composition of the silages. Although not statistically different, more true protein was conserved in treated forage sorghum and grain sorghum silage and resulting NPN levels were lower in these treated silages. Both treated maize and sunflower silage had

higher levels of WSC than their untreated equivalents. The IVDMD of inoculated forage sorghum silage was significantly lower ($P < 0,01$) than the untreated equivalent. The production of volatile fatty acids was negatively affected by inoculation, which is a favourable result, as high levels of these acids can possibly suppress silage intake. The final pH was lower in all the inoculated crops but the difference was only significant in the case of maize silage.

Rate of preservation was positively influenced in all the inoculated silages. This implies that inoculation resulted in silages achieving their final pH in a shorter time than untreated silages. This is beneficial in so far as clostridial activity, responsible for protein degradation, is limited. Despite the rate of preservation being increased by inoculation, the untreated silage attained acceptable final pH values (between 3,93 and 4,24) which indicates that sufficient fermentation occurred for satisfactory preservation.

It was concluded that forage sorghum silage was inferior when compared to the other silages, in terms of chemical composition and IVDMD. Sunflower silage was very moist, favouring clostridial action even at low pH, and would thus require the addition of a fermentation control additive such as the inoculant. The acceptability and palatability of sunflower silage will have to be determined.

The major effect regarding inoculation was found to be the increased rate of preservation. Chemical composition was minimally affected and IVDMD suppressed slightly in three of the four crops examined. Fermentation characteristics of the treated silages were improved by the inoculant and clostridial activity limited. The high moisture sunflower silage drew the most benefit from inoculant treatment in terms of the noteworthy reduction in fatty acid production. Although inoculant treatment had a minimal effect on chemical composition, it could possibly, through the influence on fermentation, have an advantageous effect on silage intake.

N.5311/05/1/2:

LARGE STOCK: EFFECT OF STOCKING RATE AND LICK SUPPLEMENTATION ON BEEF CATTLE PERFORMANCE IN THE HIGH RAINFALL SOURVELD AREA AT THABAMHLOPE. 1976-1988

A. van Niekerk and B.D. Mappledoram

In this study, the effect of stocking rate and lick supplementation on the performance of various classes of beef cows and their progeny was investigated.

The study was conducted in two phases. During the first four-year phase, four stocking rates were applied. A total of 180 cows and calves were involved each year. During the second five-year phase, 120 cows and calves were used and three stocking rates were applied. The stocking rates were: 0,83 cows + calves/ha (Tr. 1), 1,0 cow + calf/ha (Tr. 2), 1,25 cows + calves/ha (Tr. 4) and 1,67 cows + calves/ha (Tr. 5). The very high stocking rate was terminated after the first phase of the trial. Two stocking rates were duplicated to test the effect of an urea-based lick. From the onset of grazing until the 15th of February, the animals in Tr. 1, Tr. 2, Tr. 4 and Tr. 5 had access to a mineral lick and the cows in Tr. 3 and Tr. 6 received the urea-based lick. All the animals received the urea lick from the 15th of February until they were removed from the veld. Grazing was terminated when the mean condition scores of the dams declined to 2,0. Each treatment was terminated separately.

Mean minimum temperatures varied by less than 1°C and mean maximum temperatures by less than $1,5^{\circ}\text{C}$ between seasons. Sub-zero mean minimum temperatures were recorded during June and July every year of the experiment. It was concluded that the wind-chill factor would have reduced the effective ambient temperatures during May, June, July and August to a level where they would have significantly affect animal performance. The mean annual rainfall during the study period was 928 mm, which was 85,3% of the long-term mean. Between 66% and 82% of the total annual rainfall was recorded between November and March each year.

In any particular treatment, the total metabolic mass per hectare varied by less than 6 kg between season which indicates the consistency of the stocking rates applied. Total metabolic mass per hectare increased over the first four seasons at the low stocking rates, but declined at the high stocking rates. The increase in calf metabolic mass was curvilinear.

Stocking rate was by far the most important factor affecting cow performance, accounting for 45,5% of the total variation ($P < 0,001$). Initial mass accounted for an additional 9,8% of the variation ($P < 0,001$). A total of 56,8% of the total variation was accounted for. Season, calf gain and the number of days *post-partum* accounted for less than 1,5% of the total variation.

Thirty nine per cent ($P < 0,001$) of the variation in calf gain on summer veld was attributed to stocking rate. Season contributed a further 3,6% of the total variation. Initial mass, cow mass change and age of the calf at the start of the grazing season contributed only 0,8% of the total variation. A total of 44,4% of the total variation was accounted for.

During the first phase of the experiment, the cows that had access to the urea lick during the first 100 days on veld (Tr. 3) had 15,85 % higher condition scores than the cows that had access to the mineral lick (Tr. 2). Theoretically, this improved condition score represented an additional 43 days of grazing. During the second phase of the experiment, the difference in condition score between the cows in Tr. 2 and Tr. 3 represented a theoretical, additional 24,4 days of grazing. In economic terms, the saving in winter feed costs for the urea-supplemented cows amounted to R11,50 per head.

At the very high stocking rate (Tr. 5 and Tr. 6), there was no improvement in either the growth rate or condition score for those cows with access to the urea-based lick. The provision of a urea-based lick at such high stocking rates was, therefore, economically disastrous.

The responses of the first calvers, with access to the urea-based lick, was similar to that of the mature cows in terms of improved mass gains and higher condition scores. However, the advantages of providing the urea lick the younger cows were not sufficient to be economically justifiable.

At the light stocking rates, there was no apparent justification for maintaining calves on veld for longer than 200 days. However, at the high stocking rates, weaning on the basis of the dam's condition was preferable. It is suggested that weaning should occur when the mean, or individual, cow condition is between 2,3 and 2,5. Cow condition should not be allowed to fall below 2,0.

There was very little difference in maximum loss (theoretical weaning mass) between the calves born to the mature cows and those born to the first calvers. The calves born to the first cows, however, had slightly higher ADG until weaning.

The good performance of the calves born to the first calvers is ascribed to the fact that they were born 3-4 weeks earlier than the calves born to the mature cows and consequently were able to utilise the veld more efficiently at any comparable stage of grazing. Secondly, because the first calvers calved earlier, when good quality feed was freely available, they were able to realise their milk production potential.

The mean lengths of the grazing season for Tr. 1, Tr. 2, Tr. 4 and Tr. 5 were 220, 210, 194 and 177 days, respectively. The very high stocking rate treatment was terminated after four years because of a decline in the composition of the veld, as well as a significant decline in animal performance.

The highest returns per hectare were recorded by the low stocking rate treatment (0,83 cows plus calves per hectare) and the lowest returns at the very high stocking rate.

Veld condition assessments indicated over-utilisation in all the treatments. The higher the stocking rate the greater the change in VCS.

T.5311/05/2/1:

UTILISATION OF BUSH SPECIES AS A SOURCE OF ROUGHAGE IN MAINTENANCE RATIONS FOR BEEF CATTLE IN THE BUSHVELD AREAS OF TRANSVAAL REGION.
1983-1986

G.D. de Bruin and E.E. Lademann

Thirty six oxen were divided into six groups to evaluate *Dichrostachys cinerea* and *Terminalia sericea* as a source of roughage for the survival feeding of cattle. Samples of the bush, as well as components of the bush were chemically analysed. A preliminary trial was conducted to determine the exceptability of the roughage for the cattle, as well as the daily dry matter intake, when offered *ad lib*. Using the chemical analysis of the roughage, three rations on each bush species were formulated to provide sub-maintenance, maintenance and super-maintenance levels of production. At the end of the eight-week feeding period, all the oxen were slaughtered in order to examine any damage caused to the digestive tract by the woody particals in the rations. All labour necessary for the collecting and processing of the roughage were recorded in order to obtain reliable cost norms. The regrowth of *Dichrostachys cinerea* was monitored to see whether the utilisation had an effect on bush encroachment.

The crude protein content of *Dichrostachys cinerea* for the months, May, August and November was 8,6, 5,7 and 5,4 %, consecutively. The corresponding values for *Terminalia sericea* were 4,8, 2,4 and 2,8 %. The lower feeding value of *Terminalia sericea* was also reflected in the higher daily lick intakes (203, 205 versus 214, 233 g), as well as the mass changes of the oxen. Deficiencies in the diets, as shown by the chemical analysis, were supplemented. With 40 and 45 % concentrates in the *Dichrostachys cinerea* and *Terminalia sericea* rations, respectively, live mass was maintained or slightly increased. Average daily dry matter intake of these two rations was 9,6 and 9,9 kg/ox, respectively. Rations with lower concentrates resulted in average mass losses of 22,0-31,8 kg over the entire feeding period.

Notwithstanding the higher frequency of small abomasal ulcers in oxen receiving rations with lower concentrates, no serious or permanent damage was observed in any digestive tract.

The labour necessary to collect and process this type of roughage with conventional machinery, makes

this operation expensive. Costs calculated in May 1983 per ton dry matter were R237,36 and R178,44 for *Dichrostachys cinerea* and *Terminalia sericea*, respectively.

Up to 12 young shoots ratooned from each *Dichrostachys cinerea* stem utilised.

V.5311/05/1/4:

DRY MATTER INTAKE OF BEEF CATTLE ON VELD AT GLEN. 1967-1986
E.A.N. Engels

In a series of different experiments within this facet several techniques were developed and described for studying the nutritive value of pastures with sheep and cattle under grazing conditions. The results of this facet were published in 14 scientific papers.

This study had as objective the collection of pasture samples representative of the plant material ingested by the grazing ruminant. The collection of pasture samples by means of oesophageally fistulated sheep and cattle was found to be the most reliable method at present. Samples collected manually were found to underestimate to a large extent both crude protein content and digestibility of the plant material ingested by ruminants. Sheep were found to be much more selective in their grazing behaviour than cattle.

The in vitro digestibility technique proved to be reliable for the determination of the digestibility of pastures using samples collected by oesophageally fistulated animals.

In the series of experiments the feed intake of grazing sheep and cattle was measured in a satisfactory way using indirect methods where both digestibility and faeces output per unit of time are estimated using the methods that have been developed.

The seasonal variation in chemical composition of available pasture and the voluntary intake of digestible nutrients by grazing sheep and cattle were quantified. These results were used to develop supplementary feeding programmes for sheep and cattle grazing native pasture of the central Orange Free State.

W.5311/05/2/1:

SUBSTITUTION OF LUCERNE HAY WITH AMMONIATED WHEAT STRAW AS THE
ROUGHAGE COMPONENT IN RATIONS FOR LACTATING DAIRY COWS IN THE
WINTER RAINFALL REGION. 1984-1986
E.D. d'Hangest d'Yvov

Thermo-ammoniated wheat straw (NH_3WS) was used to replace lucerne hay (LH) as roughage in the diets of lactating dairy cows, in the ratio of 100 LH: 0 NH_3WS ; 67 LH: 33 NH_3WS ; 33 LH: 67 NH_3WS and 0 LH: 100 NH_3WS . The roughage diets were fed to eight comparable Friesian/Holstein cows blocked randomly according to a balanced 4 x 4 Latin square change-over design, in a voluntary intake and milk production trial. A standard dairy concentrate was provided daily at 1% of live mass. Voluntary roughage intake ($\text{g DM/W}^{0,75}/\text{d}$) tended to decline with increasing NH_3WS inclusion, with significant ($P < 0,01$) differences occurring between diets consisting of LH only and those including NH_3WS at 67 and 100% levels. The daily milk yield of cows consuming 100 LH and 67% LH was higher ($P < 0,05$) than for cows consuming NH_3WS only.

Corresponding differences ($P < 0,01$) in 4% fat-corrected milk yield (4% FCM) were obtained between the diets containing 100 LH and 67% LH and those containing NH_3WS at 67 and 100% levels. No significant differences in milk composition were obtained, whereas daily butterfat, protein and lactose yields were affected similarly to 4% FCM.

No significant residual effects were identified for any of the parameters measured.

Margin over specified costs appeared to be highest for the roughage treatment consisting of ammoniated straw only.

• Upgrading

V.5311/07/1/1:

LARGE STOCK: THE UTILISATION OF DIFFERENT BEEF BREEDS AS MALE AND
FEMALE BREEDING MATERIAL IN PURE- AND CROSS-BREEDING AT
VAALHARTS. 1976-1988
J. Grobbelaar

Cross-breeding makes it possible to create adapted genetic material in a short period. Emphasis must be on the production of a fertile breeding cow which is adapted to the environment. For this purpose British x Afrikaner and European x Afrikaner cross-bred cows were evaluated under veld conditions in the Northern Cape.

The effect of various bull breeds were also investigated. The study thus dealt, in the wider sense, with the production and reproduction complex of breeding herds which consisted of pure and cross-bred breed types.

Six bull breeds, the Afrikaner, Bonsmara, Brahman, Charolais, Hereford and Simmentaler were evaluated in pure and cross-breeding. The Bonsmara as a cow breed was evaluated in pure and cross-breeding with the Brahman, Charolais, Hereford and Simmentaler. The female stock from the above-mentioned matings were also evaluated with the Bonsmara as bull breed.

The mean efficiency of calf production over bull breeds was the highest for the Simmentaler x Afrikaner cow type followed by the Hereford x Afrikaner. The Charolais was the most efficient bull breed. Cow productivity was the lowest for the pure-bred, Afrikaner and Charolais. The pure-breds excluding the Bonsmara, yielded a low weaner production in comparison to the cross-breds. Both large and small frame animals has a role to play in future beef breeding. The optimum size will depend on market requirements and especially climatological environment and management.

The results of the study, as regards the first generation cross-bred animals, can in practice give an indication of the success of rotational systems which incorporate the same parent breeds. The information as regards the mothering ability of the F_1 breeding cows can be applied in terminal sire cross-breeding systems. An appropriate bull breed can be selected on strength of the weaning mass of the progeny of bulls which were evaluated. A more intensive study might be expedient and simulation models can be developed. The emphasis should, therefore, preferably be on the calculation of genetic parameters.

V.5311/07/1/2:

LARGE STOCK: CROSS-BREEDING THE AFRIKANER COW WITH DIFFERENT LARGE FRAME BREEDS IN SEMI-INTENSIVE SYSTEMS AT VAALHARTS. 1973-1988

J. Grobbelaar

Cross-breeding makes it possible to create adapted genetic material in a short period. Emphasis must be on the production of a fertile breeding cow which is adapted to the environment. For this purpose, European x Afrikaner cows were evaluated under veld conditions in the Northern Cape. The effect of various bull breeds were also investigated. The study thus dealt, in the wider sense, with the production and reproduction complex of cross-bred breed types.

The Maine-Anjou, Gelbvieh, Blonde d' Aquitaine, Limousin, Chianina, Charolais, Normandie and Simmentaler were evaluated as bull breeds with the Afrikaner as cow breed. The F_1 European x Afrikaner cows were used to evaluate their efficiency as female breeding stock.

Breeding with the Blonde d'Aquitaine and Charolais bulls led to distocia. Charolais, Blonde d'Aquitaine, Gelbvieh and Maine-Anjou progeny had a high potential for growth. The Limousin x Afrikaner almost consistently yielded the highest weaner production per unit cow mass. In future research on cow efficiency prediction equations should be developed for the extensive areas.

The results of the study, regarding the first generation cross-bred animals, can in practice give an indication of the success of rotational systems which incorporate the same parent breeds. The information with regard to the mothering ability of the F_1 breeding cows can be applied in terminal sire cross-breeding systems. An appropriate bull breed can be selected on strength of the weaning mass of the progeny of bulls which were evaluated. A more intensive study might be expedient and simulation models can be developed. The emphasis should, therefore, preferably be on the calculation of genetic parameters.

V.5311/07/1/3:

LARGE STOCK: THE PRODUCTION POTENTIAL OF FEMALE CROSSES OUT OF THE AFRIKANER COW WITH LARGE FRAME BULLS AT VAALHARTS. 1973-1988

J. Grobbelaar

Cross-breeding makes it possible to create adapted genetic material in a short period. Emphasis must be on the production of a fertile breeding cow which is adapted to the environment. For this purpose British x Jersey and European x Jersey cross-bred cows were evaluated under veld conditions in the Northern Cape. The study thus dealt with the production and reproduction complex of Jersey cross-bred types. Afrikaner, Charolais x Jersey, Limousin x Jersey- and Normandie x Jersey heifers were used.

The weaned mass per year per cow mated was similar for the Charolais x Jersey and the Afrikaner x Jersey crosses. The Limousin and Normandie x Jersey crosses produced less, but still higher than the pure-bred Afrikaner. The Jersey crosses produced weaners which compared favourably with any other beef type weaner.

The results of the study can in practice give an indication of the success of rotational systems which incorporate the same parent breeds. The information with regard to the mothering ability of the F_1 -breeding

cows can be applied in terminal sire cross-breeding systems. An appropriate bull breed can be selected on strength of the weaning mass of the progeny of bulls which were evaluated.

A more intensive study might be expedient and simulation models can be developed. The emphasis should, therefore, preferably be on the calculation of genetic parameters.

• Management

N.5311/41/1/3:

LARGE STOCK: EFFECT OF WINTER GROWTH LEVELS AND STOCKING RATES ON THE HIGH RAINFALL SOURVELD ON THE DEVELOPMENT OF BEEF CATTLE HEIFERS AT THABAMHLOPE. 1981-1989

A. van Niekerk, B.D. Mappedoram and R. Kernick

The effect of three winter nutritional levels on subsequent summer performance of weaner/replacement Simmentaler heifers when stocked at three stocking rates over four seasons was investigated. The three winter nutritional levels were constantly adjusted to achieve growth rates were -0,1 kg/day, +0,25 kg/day and +0,5 kg/day. The three stocking rates were 0,75, 1,0 and 1,25 AU per hectare. Summer grazing generally commenced in November and was terminated in May each year. The heifers were fed during the second winter so as to achieve a target mating mass of 340 kg by mid-October. The study was carried out at the Tabamhlope Research Station which is situated at an altitude of 1450 m above sea level, within Bioclimate 4e in Natal, RSA.

The mean annual rainfall over the four-year period was 822,7 mm which was 75,6 % of the long-term mean. Approximately 72 % of the mean annual rainfall was recorded between November and March. The mean maximum temperature was 27,7 °C and the mean minimum temperature 6,1 °C. Season did not significantly affect mean maximum and mean minimum temperatures.

During the 1984/85 season, both the winter nutritional level and stocking rate affected the performance of the heifers on summer veld. The heifers wintered at the low level had significantly ($P < 0,01$) higher ADG at all three summer stocking rates, than the heifers wintered at the medium level, which in turn had significantly ($P < 0,01$) higher ADG than the heifers wintered at the high level.

During the 1984/85 season, the heifers at the low stocking rate attained significantly ($P < 0,01$) higher ADG than the heifers stocked at the high stocking rate, irrespective of the winter nutritional level.

The heifers wintered at the low level during the second winter, achieved significantly higher ($P < 0,01$) growth rates on summer veld than the heifers wintered at the medium and high levels. There was generally no difference in summer growth rates between the latter two groups, except at the light stocking rate.

There was generally no stocking rate related differences in performance between the various treatments, during the 1985/86 season.

It was concluded that full compensatory growth was possible during the first season because the camps had benefitted from a full season's rest. During the second season, the camps were only rested during the winter months, prior to the onset of the grazing season, and consequently there was less herbage available during the 1985/86 season, a factor which affected the performance of the heifers.

During the 1984/85 season, the heifers wintered at the low level and subsequently stocked at a low stocking rate, realised the lowest total feed costs - R58,13. The highest feed costs were attributed to the heifers wintered at a low level and subsequently stocked at a high stocking rate - R122,84.

The heifers wintered at a medium level and subsequently stocked at a low stocking rate, during the 1985/86 season, realised the lowest feed costs - R79,44, whereas the heifers wintered at the low level and subsequently stocked at a high stocking rate, incurred the highest feed costs - R117,59.

It was concluded that heifer rearing in the Highland Sourveld is predominantly an economic issue and that a conservative approach should be adopted, i.e., mass gains in the region of 0 - 0,25 kg/day during the first winter, followed by a low stocking rate (0,75 AU/ha) on summer veld.

A total of 106 heifers were utilised in the experiment during the 1984/85 season. Of these, two were culled and three died of natural causes; 101 were mated; 97 (96 %) were diagnosed pregnant and 95 (94 %) calved.

All the heifers calved within the first 30 days and 20 days of the first and second calving seasons, respectively. This implies that the time of conception was not affected by treatment.

Thirty of the 44 heifers that calved for the first time in 1984, produced three calves in three years. Thirteen heifers (30 %) produced two calves in three years. The data suggests that there was no effect of *pre-partum* treatment on subsequent calving performance.

N.5311/41/2/1:

LARGE STOCK: PERFORMANCE OF DUAL PURPOSE AND BRITISH BEEF CATTLE ON KIKUYU PASTURE IN THE HIGH RAINFALL SOURVELD AREAS AT CEDARA. 1975-1985

B.P. Louw, P.E. Bartholomew, C.I. Macdonald and C.R. Thomas

The main aim in characterising kikuyu was to provide realistic information for planning cow-calf systems. To

this end it is considered that the facet, monitored over a period of nine seasons, provided much useful information. Conclusions that can be drawn from the facet are as follows:

- There was a highly significant positive relationship between seasonal rainfall and pasture dry matter yield.
- Kikuyu yields can be determined with the pasture disc meter.
- Maximum growth from kikuyu can be expected towards the end of February or early March.
- There was a highly significant linear relationship between herbage on offer and apparent dry matter intake.
- There was a highly significant negative linear relationship between stocking rate and daily gain per calf and between stocking rate and calf live mass gain per season.
- The larger Simmentaler type animals had lower stocking rates providing for maximum calf live mass gain per season than did the lighter Hereford type animals.
- Simmentaler calves had approximately 12,6 % better performance than the Hereford type calves. For both breeds the steer calves had, on average, a 6 % higher performance than the heifer calves.
- For most seasons maximum mass of the cows was attained during march.
- There were found to be highly significant relationships between:
 - (a) stocking rate and period on pastures for the cows,
 - (b) live mass gain of the calves and time to attain maximum mass at different stocking rates,
 - (c) stocking rate and period on pasture for the cows (data is provided on the length of the winter feeding period), and
 - (d) cow mass change as dependant rainfall (affecting herbage production), period on pasture and stocking rate.
- An increase in stocking rate from 2,9 to 7,3 cows and calves/ha was associated with a decrease in calf live mass gain, a decrease in calf live mass gain, a decrease in milk production, an increase in the production of beef per hectare and a decrease in margins over feed costs per cow.
- Stocking rate did not influence reconception rates, which averaged 65 % over the nine seasons.
- Simmentaler cows produced approximately 1,4 litres of milk more per day, lost more condition and attained higher margins over feed costs per cow and per hectare than Hereford-cross cows.
- Season influenced the length of the grazing season, birth mass, live mass gains in calves and mass changes in cows.
- Milk production accounted for 40 % of the variation in calf gains on pasture. The conversion of milk to calf gain was influenced by milk yield, stocking rate, breed and calf sex.

W.5311/41/1/1:

LARGE STOCK: EVALUATION OF SHELTERS FOR DAIRY COWS IN THE WINTER
RAINFALL REGION. 1981-1983

C.J.C. Muller

Material and methods

The milk production and health of dairy cows in an intensive housing unit and open camp system were compared. Friesland cows from the Elsenburg herd were allocated according to lactation number and calving date to two comparable groups of 10 cows each. Cows were permanently kept in either an intensive housing unit or an open camp. Milking was twice daily and milk production was recorded at each milking. Milk composition, mastitis and footrot incidences were also recorded daily. Maximum and minimum temperatures were recorded inside the housing unit and outside in the open camp in a Stevenson screen. The annual costs of an intensive housing unit and an open camp housing 180 cows were calculated and compared.

Results and discussion

Owing to the small number of available experimental animals, the two groups of cows were not comparable in terms of milk production before the start of the experiment. It is, therefore, difficult to conclude that differences in milk production and composition between the two groups may be ascribed to a specific treatment.

It is, however, expected that adverse climatic conditions may influence the milk production of cows. By comparing the milk production of cows in the housing unit and open camp on rainy days during winter and

hot days (maximum temperature above 27 °C) during summer to the previous day's production, it is possible to determine the protection provided by the housing unit.

Rain reduced the milk production of cows in the housing unit and open camp significantly ($P = 0,05$) from 15,23-14,79 and 14,40-13,82 kg per day, respectively. This is possibly due to the position of the feeding trough in relation to prevailing winter winds.

Temperatures above 27 °C reduced the milk production of cows in the housing unit significantly ($P = 0,05$) from 16,05-15,83/kg per day. This reduction may be attributed to a high heat load inside the building because of the low roof of the structure. The back wall of the building reduced the flow of air and prevented animals from cooling down. The milk production of cows in the open camp was not significantly affected. Although cows in the open camp were exposed to direct solar radiation, it seems that prevailing summer winds caused a cooling effect.

The number of mastitis incidences among cows in the housing unit was higher possibly because of poor design and management of the sleeping stalls. Cows in the building developed more foot problems owing to the concrete floors.

Climatological data indicate that the average monthly maximum temperatures were higher in the housing unit than in a Stevenson screen in the open camp. This difference could possibly be attributed to radiation heat from the roof. In the immediate vicinity of the open camp and housing unit there was less wind than at the Elsenburg weather station owing to the close proximity of buildings and various rows of trees.

The annual cost of an intensive housing unit is approximately R70,00 higher per cow than an open camp system. An efficient housing system should, however, increase milk production.

W.5311/41/2/1:

THE DETERMINATION OF THE MASTITIS INCIDENCE USING A FOSSOMATIC
SOMATIC CELL COUNTER AND ITS VALUE IN MASTITIS MANAGEMENT
PROGRAMMES IN DAIRY CATTLE IN THE WINTER RAINFALL REGION. 1984-1987
J.G. Conradie

Material and methods

The facet was conducted in three phases. Firstly, information on adjacent parallel quarter comparisons gathered from 400 dairy cows, was used to identify the influence of mastitis on milk yield and chemical composition (butterfat, protein and lactose). The second stage concentrated on the actual determination of the magnitude of mastitis in approximately 2 000 dairy herds in the Winter Rainfall Region, whereas the third phase involved the circulation and evaluation of an extensive questionnaire among 1 950 dairy farmers. The latter concerned farm management policies associated with the prevention, control, diagnosis and treatment of mastitis. The response to 50 various aspects in this regard were evaluated against a three-year herd somatic cell count (HSCC) history.

In order to obtain relevant information, some 50 000 milk samples including fore, quarter, udder and bulk milk were collected. Where applicable, milk samples were subjected to analyses using a fossomatic somatic cell counter, a milkoscan infra-red apparatus and the California mastitis test (CMT) to determine respectively, somatic cell count (SCC), butterfat, protein and lactose contents, as well as CMT scores.

Conclusions

Owing to the vast nature of this investigation, it is not possible to provide detailed results in this summary.

In general, the negative influence of mastitis on milk production characteristics (milk yield, butterfat, protein and lactose content) was clearly demonstrated. Comparisons between adjacent parallel quarters showed a loss of 0,39 kg milk (27,1 %) per milking when normal quarters (SCC less than 250×10^3 per mℓ) were compared with those having a SCC of more than $1\,000 \times 10^3$ per mℓ. Mean butterfat yield decreased at the same time by 29,2 %, mean protein yield by 25,2 % and mean lactose yield by 32,4 %. These losses were all associated with a SCC increase of $3\,036 \times 10^3$ per mℓ milk.

The systems of "predicting cell counts" by including both the SCC and milk yields of individual quarters and udders in order to define relationships between quarter, udder and bulk milk SCC, proved to be a satisfactory method. High coefficients of correlation were obtained between the SCC's of fore milk and quarter milk ($r = 0,92$), quarter milk and udder milk ($r = 0,96$) and between udder milk and bulk milk ($r = 0,98$). It appears, however, that a perfect relationship existing between bulk milk SCC and the incidence of mastitis in quarters or udders, is unlikely.

The mean SCC of defined CMT scores (i.e. trace, 1, 2 and 3) was found to be in agreement with those described in the literature. The wide variation in SCC for each CMT score (trace: 23×10^3 to $1\,087 \times 10^3$ per mℓ; CMT 1: 75×10^3 to $2\,870 \times 10^3$ per mℓ; CMT 2: 209×10^3 to $11\,051 \times 10^3$ per mℓ and CMT 3: 724×10^3 to $27\,288 \times 10^3$ per mℓ) strongly suggest that treatment of infected quarters based on the CMT as only criterion, may prove to be highly unsatisfactory. It is, therefore, concluded that the CMT must be seen as a management aid only.

With regard to the magnitude of mastitis in the Winter Rainfall Region, information gathered from about 46 000 respondents, monthly herd SCC observations over a three-year period, indicated that in only 33 % of the cases a herd SCC of less than 250×10^3 per mℓ milk could be obtained. A slight improvement (-4,1 %), i.e. a reduction in the number of herds with a SCC in excess of 750×10^3 per mℓ, was observed when the third year of the investigation was compared to the second. It is believed that this result can be attributed mainly to the regular monthly feed back of herd SCC data to milk producers.

Results compiled from nearly 1 200 replies to the questionnaire concerning mastitis prevention and control policies, suggest that a large number of producers are applying ineffective mastitis control measures. Problem areas in this regard are a lack of hygienic calving facilities, unsatisfactory milking procedures (udder preparation, milking hygiene, teat dip), unskilled milking operators and insufficient experienced supervision. The method of evaluating the above control methods against herd SCC, proved to be highly satisfactory in 75 % of cases.

SMALL STOCK

• Reproduction

V.5312/04/1/3:

THE EFFECT OF BODY MASS ON REPRODUCTION OF THE KARAKUL EWE. 1985-1987
A.S. Faure

The influence of body size, condition and mass on the reproduction of the Karakul ewe was investigated during seasonal anestrus ($n = 96$) and the breeding season ($n = 96$). Variation in body condition and mass was initiated by the application of three levels of feeding and consisted of a sub-maintenance (P^-), maintenance (P^+) and maintenance plus (P^+) diet.

Feeding took place over a period of 14 weeks, with the commencement of natural mating for 24 days after 8 weeks of feeding. Body size (withers height, withers to ischium length, chest width, depth and circumference) was determined at the commencement of the investigation, as well as a subjective assessment of body condition, with the latter repeated at mating.

Body mass was determined at weekly intervals throughout the feeding period. Reproduction was evaluated in terms of the percentage ewes showing oestrus, the number of ovulations per ewe, percentage of ewes lambed and lambs born. Ovulation rate was determined by laparotomy 6 days after oestrus.

The percentage ewes in oestrus and ovulation rate in both seasons did not differ significantly ($P > 0,05$) among the feeding treatments. Whereas the percentage of ewes that lambed as a result of mating during both seasons decreased in the feeding treatment order P^0 , P^+ to P^- . However, no significant ($P > 0,05$) relationship existed between conception and or embryo survival and the body parameters (size, mass or condition) or the change in these parameters during the feeding period.

Except for possible extremely low and high values for size, mass or condition, no critical value was evident for normal reproduction in the Karakul ewe in this investigation.

• Nutrition

D.5312/05/1/3:

SMALL STOCK: THE INFLUENCE OF STOCKING RATE, WHOLE GRAIN FEEDING AND RUMEN BUFFERS ON THE PRODUCTION RESPONSE OF EWES AND LAMBS IN THE SOURVELD. 1984-1988
W.P. Henning

The high demand for mutton and wool necessitates that alternative lamb production systems to green-feed be developed, especially in the high potential areas like the sourveld. Any potentially economic and viable system would require the incorporation of the natural veld combined with strategically planned supplementation.

In this study energy supplementation to the lactating grazing ewe in the form of caustic soda-treated or untreated maize, grain or cobs was combined with rumen stimulating protein-energy licks. In addition two

grazing pressures were applied at dry matter availability of 3 or 6 kg ewe d⁻¹. Thus in a 3:2:2 factorial set of treatments (12), with 7 ewes and lambs per treatment, maize or cobs were fed every three days at levels of zero or 300 g/ewe d⁻¹. Lambs received a creep feed up to the age of weaning (60 days).

A digestion study was also carried out to investigate the effect of these energy supplementations on the rumen pH as well as intake and digestibility of sour veld grass. In a second trial, maize was fed to experimental groups (10) of ewes and lambs at 300, 600 or 900 g/ewe d⁻¹.

Energy supplementation (range 300 to 900 g/ewe/d⁻¹) in the presence of protein energy licks to lactating ewes grazing early winter sourveld reduced the loss of body mass by 19 %, but was not successful in alleviating such stress altogether. There was no advantage in maize supplementation levels above 300 g/ewe d⁻¹. NaOH treatment of the energy sources exerted no influence whereas grazing pressure played a minor role (loss 77 versus 87 g/ewe d⁻¹). Energy supplementation to the ewe increased the lamb growth rate with 11 to 15 %.

Lamb growth was not affected by caustic soda treatment, whereas a varied response was observed for grazing pressure. Grass intake did not differ (764 ± 16,95 g) between treatments, although caustic soda treated supplements caused an apparent increase in grass intake (725-803 g/head d⁻¹). Similar supplementation with cobs resulted in an apparent higher grass intake (818 g) than obtained with whole grain (717 g). An apparent increase in DM-digestibility was also evident with both caustic soda treatment (59,6 versus 57,8 %) as well as supplementation (57,2 versus 59,4 %). It thus appears that a viable and economic lamb production system could be developed with strategic supplementation of natural sourveld.

D.5312/05/2/1: SMALL STOCK: INFLUENCE OF NUTRITIONAL STRESS ON THE INCIDENCE OF ABORTION IN BOER GOATS. 1982-1989

W.A. Coetzer, C.H. van Niekerk, P.R. King and H.H. Barnard

Aspects related to the incidence of abortion in the South African Improved Boer goat were investigated under the guidance of the Department of Agriculture and Water Supply (Agricultural Centre, Dohne, Eastern Cape Region) and by the Department of Human and Animal Physiology (University of Stellenbosch, Stellenbosch).

Nutrition - the effect of undernourishment on the occurrence of abortion and plasma progesterone levels in the Improved Boer goat

An outbreak of abortion (15-40 %) occurred in a governmental flock of Improved Boer goats in the Eastern Cape area. As tests for the most obvious infections proved negative, a more intensive investigation was undertaken. Results obtained from a countrywide survey indicated "undernutrition" as a possible cause of abortion. A programme covering two consecutive years was designed whereby pregnant does were subjected to various degrees of nutritional stress. Treatment of pregnant does included excessive underfeeding under pen conditions for a three week period, poor veld grazing and good veld grazing (controls).

The course of pregnancy was monitored by frequent plasma progesterone determinations and intensive visual observation. During both years, the severely undernourished group averaged a mass loss of 15-19 % over three weeks. Despite the severity of treatment, no abortions were observed. This was confirmed by the progesterone profiles. In none of the does did the progesterone levels show any abnormal decline in concentration. On the contrary, progesterone levels showed a tendency to increase 5-10 ng/ml above the normal pregnancy values during nutritional stress.

A similar compensatory reaction was reported in sheep (Faure, 1975) whereas a drastic fall in plasma progesterone occurs in the Angora goat (Wentzel, 1973) and thoroughbred mare (Morgenthal & Van Niekerk, 1984). It is concluded that undernourishment is not a cause of abortion in the Boer goat. It may, however, create a stress situation whereby certain pathological conditions may cause abortion.

Animal physiology - a study on certain aspects of the reproduction physiology of the Improved Boer goat doe

The incidence and hormonal profiles of the oestrous cycle, pregnancy and for induced abortion in the Improved Boer Goat were investigated. The 15 animals were kept under pen conditions and on kikuyu grazing at Welgevallen Research Farm, University of Stellenbosch, Stellenbosch.

The two months prior to the beginning of the mating season (1 April) was characterised by a reasonable degree of sexual activity (73,3 %). The does showed rhythmical oestrous cycles of 21,2 days on average, whereas plasma progesterone values reached normal cyclical levels equal to that during the active mating season.

According to the progesterone profiles, two of the does (13,3%) showed no sexual activity at the start of the study. At first the progesterone levels were low ($\pm 0,5$ ng/ml) and later increased to a maximum of respectively, 3,8 and 6,0 ng/ml. These increased values were observed over a period of 173 days. In two other does the progesterone values were not very low (± 1 ng/ml) and in both cases decreased further before a final increase prior to first heat was determined. This increase lasted 10-14 days and maximum progesterone concentrations of 2,3-4,0 ng/ml were attained. It is, therefore, accepted that silent ovulations occurred in these four does (26,6%) during the investigation.

The duration of the oestrous cycle and oestrous period during the mating season (April) averaged 21,2 days and 38,0 hours, respectively. The plasma progesterone concentrations during the first three days after commencement of oestrus were below 0,5 ng/ml. After that it gradually increased daily to a peak of between 5 and 8 ng/ml on days 17 and 18. Three to four days prior to the following oestrous period, the progesterone concentrations decreased rapidly and it was below 0,5 ng/ml at the start of oestrus.

Lutinisig hormone (LH) peaks occurred between 12 and 18 hours after commencement of the oestrous period and the values varied between 12,2 and 30,0 ng/ml. Basal LH concentrations (0,5 ng/ml) were observed before and after these peaks during the rest of the oestrous period.

The average length of pregnancy in the Improved Boer Goat was 152,2 days (148-155 days). These values were found with does bearing multiple fetuses. Directly after mating plasma progesterone concentration followed the same pattern as during the normal oestrous cycle. A slight decrease in progesterone levels was observed on day 17 and approximately days 50-60 after mating. The stage of these decreases corresponds with the natural degeneration of the *corpus luteum* during the normal oestrous cycle as well as the period during which, according to surveys, abortion takes place. During the rest of the pregnancy period the progesterone concentrations varied on a high level from 9-11 ng/ml. The progesterone concentration started decreasing rapidly at approximately two to three days before partus and 24 hours before partus it was 1,0-3,0 ng/ml and during partus the progesterone levels were below 1,0 ng/ml. Increased plasma glucocorticoid concentrations (10,3-27,0 ng/ml) were observed just before the decrease in progesterone levels and it lasted for approximately 36 hours.

Abortion was brought about by respectively, ovariectomising pregnant Boer Goat does, ligating the umbilical cord by way of abdominal histiotomy and by administering a PGF_{2x} analogue ("Lutalyse").

On average abortion occurred 30 hours after ovariectomy. The plasma progesterone levels decreased from between 9,5 and 14,0 ng/ml-2,0 ng/ml within eight hours. This decline continued and at the time of abortion, the plasma progesterone concentrations were approximately 1 ng/ml (0,5-1,2 ng/ml).

The pattern in the decline of progesterone levels after ligation of the umbilical cord differed in the cases where one of the multiple fetuses died compared to instances where the flow of blood to all fetuses were cut off. In the first case, the plasma progesterone levels decreased precariously over a longer period, namely from 14,5 and 22,0 ng/ml to 1,3 and 2,0 ng/ml during abortion, which occurred 90-106 hours after the operation.

When total fetus decrease was accomplished, the plasma progesterone concentrations showed a sharper and more even decline. It decreased from 15,7-1,0 ng/ml during abortion 66 hours after the operation.

The plasma concentration of a metabolite of PGF_{2x}, i.e. 13,15-dihydro-15-ket-prostaglandin F_{2x} showed an increase of 50-100 pg/ml immediately before the sharp decrease in plasma progesterone concentrations. The increased concentrations were generally coupled to a decrease in progesterone levels. Administration of 6,0; 4,5; 3,0; 1,5 and 1,0 mg prostaglandin F_{2x} analogue, respectively caused abortion in 14-week-pregnant Boer Goat does. A sharp decline in plasma progesterone concentrations to basal values (0,5-1,5 ng/ml) was observed with all treatments within 12 hours after administration. On average abortion took place 44,8 hours (35-53 hours) after PGF_{2x} administration.

In those cases where 0,5 and 0,1 mg "Lutalyse" respectively, were administered, abortion did not take place. In both cases slight decreases in plasma progesterone concentrations were observed, but after approximately 24 hours it returned to pre-treatment values. Where abortion occurred after "Lutalyse" administration, increased plasma glucocorticoid concentrations were only observed during partus. In the does that did not abort (0,5 and 0,1 "Lutalyse") the glucocorticoid levels generally varied between relatively low limits 1,0-10,0 ng/ml).

According to the results obtained during induced abortions it is likely that:

- the Boer Goat doe is dependant on the *corpus luteum* as a source of progesterone for the full duration of pregnancy;
- the placenta of the Boer goat doe probably also produces a luteotropic factor (possibly placental lactogen);
- the hormonal relationships during abortion differ from that during normal partus;
- the time lapse during which the progesterone decrease occurs, may be an indication of the cause of abortion.

P.G. Marais

The supplementation of grazing for ruminants with mineral and rumen stimulating licks has lately become a sophisticated practice in South Africa. Although the supplementation of grazings with phosphorous has been propagated and practiced in South Africa since 1920, the nutritional requirements of sheep for this element is still uncertain. The principle of rumen stimulating licks is based on the fact that apart from the necessary phosphorus being supplied to the animal, nitrogen and energy are supplied in such quantities that rumen fermentation is stimulated and accelerated.

The main object of this study was to evaluate the influence of supplementation of energy and protein with and without phosphorus, on wool production and reproduction of six groups of 30 Merino ewes each on four different Karoo veld types on the Carnarvon Experimental Station.

An attempt was made to regulate the intake with NaCl to such an extent that dry ewes consume 100 g of supplementation/day and late pregnant and lactating ewes 200 g/day/ This trial ran from 1977 till 1982.

According to the average intake of the different treatments, no significant difference could be detected between treatments within the same season on the same veld type. The average live mass of ewes did not differ significantly between treatments/season/veld type. Significant differences between the different average daily gains and corrected weaning mass of lambs per treatment per year did not exist, but significant differences between years did exist. According to the reproduction and wool production data no significant differences between treatments/year could be detected.

It was thus significant that additional supplementation on the four different veld types did not have any advantages for the small stock farmer.

A.D. Lyle

The influence of a calcium phosphate supplement on the performance of approximately 200 Merino breeding ewes which lambed annually in April was studied over a period of eight years at the Kokstad Research Station.

The ewe flock was subjected to four treatments, namely the provision of a calcium phosphate (Ca P) supplement throughout the year, a Ca P supplement in summer, a Ca P supplement in winter and a control, which received no Ca P supplement. All the sheep were run as a single flock and the supplements were provided by dosing 32 g of monocalcium phosphate (later changed to dicalcium phosphate) twice a week. The flock received salt at all times *ad lib*.

The sheep grazed summer veld from October to March. The ewes lambed on the veld and thereafter were drafted onto irrigated rye grass pasture or dryland oat greenfeed until the lambs were weaned in mid-July. The lambs remained on the pasture until October and the ewes were fed good quality *E. curvula* hay with a protein lick for the same period.

The Ca P supplement had no effect on the body masses and wool production of the ewes. Lamb weaning masses were not affected by treatment. There were no statistically significant differences in lambing percentage but there was a persistent tendency for the ewes supplemented with Ca and P during summer and winter to have higher lambing percentages than the ewes supplemented with Ca and P all year and the control ewes. Chemical composition of blood, bone and dung samples were not significantly affected by treatment.

An additional trial involved an investigation into the effect of a Ca P supplement on the performance of 147 Merino lambs from weaning to two and a half years of age. Treatment had no significant effect on body masses, wool masses or chemical composition of blood serum. Lambing percentages in the 83 maiden ewes were 59 % in ewes supplemented with Ca P and 76 % lambing in the control group ($P < 0.05$).

At two years of age the wether lambs were drafted into a trial in which the effect of various combinations of protein, phosphate and energy supplements on winter veld was investigated. Protein was the only nutrient that prevented body mass loss in wethers on winter veld.

It was concluded that Ca P supplementation exerted no significant effect on the performance of lambing ewes and lambs from birth to two and a half years of age, on the summer and winter feeding regime used in this trial. Longer periods of veld grazing than used in this trial and inadequate fertilisation of winter pastures could possibly change the response of Ca and P supplementation in the breeding flock.

An investigation was conducted on the supplementation of protein and energy to pregnant Dohne Merino ewes on winter veld in the South-eastern Transvaal Highveld. Fish meal and maize meal were used as sources of protein and energy and the design of the experiment was such as to allow the separation of the individual effects of protein and energy by partial regression analysis.

Protein was found to be the main limiting factor in the maintenance of a satisfactory body mass during winter, whereas some additional energy during winter was advantageous with regard to the subsequent performance of offspring born on summer grazing. The effect of the supplementations on wool growth and quality are discussed.

The effect of phosphorus (P) supplementation to Dorper ewes and their lambs on the performance of the sheep, whereas grazing either intact Vaalbos veld (control) or veld where the naturally occurring bush component had been removed (treated), was studied at Koopmansfontein on the Ghaap plateau. On both the control and treated veld, two groups of sheep had *ad lib.* access to either a salt (-P) or a salt/P (+P) lick, respectively. The lambing intervals of the ewes were reduced, thus producing 10 lamb crops during the trial period of 7 years.

The effects of P supplementation and removal of the bush component on diet selection, feed intake of the lactating ewes, reproductive performance of the ewes, body mass changes of the ewes and their lambs and mineral concentrations of blood and rib bone samples of the ewes and their lambs, were studied.

Diet selection was not influenced by P supplementation. However, organic matter digestibility (DOM) of the diet selected by oesophageally fistulated (OF) sheep on the treated veld was consistently higher than on control veld. This was linked to the selection of substantial quantities of the bush component by the sheep on the control veld, especially during winter. By contrast, the crude protein (CP) content of the diet on the treated and control veld, as selected by OF sheep was virtually the same. Both CP and DOM on the treated as well as the control veld evinced a strong seasonal pattern, being lower during the winter.

Removal of the bush component, as well as P supplementation, had little effect overall on animal performance as reflected in body mass changes of the ewes and their lambs. However, the positive effect of P supplementation was discernible in the elevated reproductive performance of the ewes, as well as in the higher mineral concentrations of their rib bones. The reduction in lambing interval was clearly instrumental in a progressive depletion of body reserves in the reproducing ewes, thereby inducing an apparent P deficiency and the observed response to P supplementation.

It was concluded that adherence to the more conventional lambing interval of 12 months, as well as by synchronising the lambing season to coincide with the potential of the veld to provide in the higher nutrient requirements of lactating ewes, an overall higher level of animal performance and meat production would have been possible.

In this study an effort was made to measure the nutritive value of oat pasture for Merino sheep. Eighty Merino wethers ranging from six to nine months of age were used in the trials. Complete energy balance trials were conducted in 1968, 1969 and 1971. The comparative slaughter technique was used to measure energy gain over the experimental periods in the Merino wethers.

In the 1968, 1969 and 1971 trials the average organic matter (OM) digestibility of the oat pasture were 84.3, 84.1 and 83.3%. The faecal energy loss ranged from 16.7 to 21.6% in the different trials. The urinary energy loss was found to be approximately 5% of gross energy ingested. The average metabolisability of digestible energy (DE) were 83.1, 83.2 and 83.7% in the 1968, 1969 and 1971 trials.

It was calculated from the results of this study that the calorific values of digestible organic matter (DOM) were 19.4 kJ DE and 16.0 kJ metabolisable energy (ME), respectively.

The average estimated energy requirement for maintenance of grazing sheep was found to be 48% higher than that of pen fed sheep.

W.5312/05/3/1:

THE TREATMENT OF WHEAT STRAW WITH UREA AND ITS UTILISATION BY SHEEP DURING THE SUMMERTIME IN THE WINTER RAINFALL CROPPING AREA. 1981-1986

A.A. Brand

Material and methods

The experiment was conducted in three distinct phases. The first phase involved two laboratory trials in which various treatment conditions affecting urea ammoniation were assessed. The first trial investigated the effects of temperature (4, 14, 24, and 35 °C), moisture level (25 and 37,5 %) and treatment period (0, 1, 2, 4, 6 and 8 weeks), whereas the effects of physical form (long and ground), moisture level (25, 37.5 and 50 %) and prolonged treatment period (0, 4, 8, 12, 24 and 48 weeks) were addressed in the second trial. The various treatments were assessed by determinations of in vitro organic matter digestibility, as well as by nitrogen, urea and free ammonium content.

A voluntary intake and in vivo digestibility trial was conducted to evaluate urea-ammoniated wheat straw (AWS) against an untreated control (UWS), and UWS supplemented with urea to the nitrogen level obtained in AWS (SWS). The straw used for this purpose was treated in bales in a stack. The treatment conditions were 5 % urea, 40 % moisture and a treatment period of 8 weeks.

The final phase of the experiment involved an investigation into the suitability of AWS for the oversummering of pregnant and lactating S.A. Mutton Merino ewes. AWS was used to replace SWS in three diets to contribute 100, 50 and 0 % of the total roughage in the respective diets. The diets presented during late pregnancy included 40 % concentrate and 60 % roughage, whereas the lactation diets contained concentrate and roughage in a 50:50 ratio. The ewes were kept under zero grazing conditions from 6 weeks before lambing up to the early weaning of their lambs at 67 ± 8 days. Daily dry matter intake, live mass and plasma glucose levels were recorded with regard to the ewes, whereas live mass, survival and pre-weaning growth were measured in the lambs.

Results and conclusions

Urea ammoniation was markedly accelerated by an increase in temperature up to 35 °C. There was evidence of a slower release of ammonia from urea at 35 °C, possibly as a result of retarded urease activity at this relatively high temperature. In both laboratory studies, ammoniation was faster and more effective at higher moisture levels. Ammoniation was slower and less effective in long wheat straw than in ground wheat straw. Practical considerations do, however, favour the treatment of long wheat straw. AWS could be stored for so long as 48 weeks without evident signs of deterioration. Significant interactions of treatment period with temperature, moisture level and physical form indicated that the slower reactions at low temperatures and moisture levels, as well as of long wheat straw could partially be provided for by treatment for longer periods.

In the second phase of the experiment, it was found that urea ammoniation and urea supplementation improved the voluntary dry matter intake/ $W^{0.75}$ of UWS by sheep by 47 and 36 %, respectively. The difference of 8 % in favour of AWS in comparison with SWS was not significant. Urea ammoniation also improved the dry matter digestibility of wheat straw in relation to both UWS (17.5 %) and SWS (10.0 %). Both urea ammoniation and urea supplementation improved the crude protein digestibility of wheat straw markedly. The crude protein digestibility of SWS was 25.3 % higher than in AWS, indicating that some of the protein added to the straw by ammoniation was not readily utilised by the rumen microbes. Urea ammoniation improved the digestibility of neutral detergent fibre, acid detergent fibre and hemicellulose significantly when compared with UWS and SWS. The nitrogen balances of AWS and SWS were similar and significantly higher than in UWS.

With regard to the third phase of the experiment, it was found that the energy content (in vitro organic matter digestibility) of the diets presented during late pregnancy and lactation increased with increasing levels of AWS. The voluntary intake on all three diets were relatively low throughout the duration of the experiment, a result which may be related to the bulkiness and/or unpalatability of wheat straw as a roughage source.

The plasma glucose concentration of the ewes was relatively low over the entire experimental period (44 ± 10 mg/100 ml), and was unaffected by the level of AWS inclusion. The only significant differences in live mass occurred during the last four weeks of lactation, when the ewes consuming 100 and 50 % AWS as

roughage were heavier than those on the diet containing only SWS. The progeny of ewes consuming the respective diets did not differ significantly with regard to birth mass, weaning mass as well as preweaning growth and survival.

It was concluded that the advantage of AWS over SWS in late pregnancy and lactation diets containing 40-50 % concentrate, was limited. Diets of a similar nature could, however, be fed to pregnant and lactating ewes under conditions of feed scarcity.

W.5312/05/5/1:

UREA AMMONIATION OF ROUGHAGES FOR SHEEP IN THE WINTER RAINFALL
CROPPING AREA. 1984-1987

A.A. Brand

This study can be divided into three phases, namely laboratory experiments, metabolic experiments and the evaluation of ammoniated wheat straw in production diets for sheep. The purpose of the laboratory experiments was to determine the optimum conditions for separate and combination treatment of wheat straw with urea and caustic soda (NaOH), as well as the optimum treatment conditions for the ammoniation of wheat, oat and barley straw and oat hay with urea.

The optimum treatment conditions obtained were applied to determine the separate and combined efficiency of treatment of wheat straw with urea and NaOH during baling, and to investigate the effect of type of straw (wheat, oat and barley) and oat hay on the efficiency of urea ammoniation. Further metabolic experiments also investigated the effect of energy (20 % maize meal) and protein (5 % fish meal) supplementation of untreated wheat straw, urea supplemented and urea-ammoniated wheat straw on the utilisation of the straw, and the effect of substitution of lucerne hay with untreated, urea supplemented and urea-ammoniated wheat straw.

In the production experiment lucerne hay was substituted stepwise by urea-ammoniated wheat straw. These diets, which included 60 % roughage and 40 % concentrates, were fed to lambs in a growth experiment for 84 days. Also investigated was the effect of hammermill screen size and pelleting on the voluntary intake and growth of replacement ewes fed on ammoniated wheat straw for 84 days.

Results and conclusions

Because of the extent of the study, no specific results will be given in the summary. Only the most important conclusions will be presented. The combination treatment of wheat straw with urea and NaOH caused a substantially slower rate of urea degradation, suggesting a depression of urease activity owing to the inclusion of NaOH. The *in vitro* organic matter digestibility (IVOMD) of the combination treatment of wheat straw was substantially higher than that of the separate urea and NaOH treatments. However, in the *in vivo* digestibility trial no additive effect of the combination treatment with urea and NaOH on the organic matter digestibility was found, but voluntary intake was higher on straw treated in this way.

An interaction between treatment period and moisture level, as well as urea level was found, indicating that the level of urea ammoniation at lower moisture levels can be improved by increasing the treatment period. It was, however, evident that 30 g urea/kg wheat straw was not sufficient for effective treatment, and that extending the treatment period had no advantage. The voluntary intake of treated oat hay was higher than that of treated oat straw and tended to be higher than that of treated wheat straw and barley straw. Little variation in the apparent digestibility of dry matter (DM) and organic matter (OM) was found between wheat, oat and barley straw and oat hay. The rate of passage of the treated wheat, oat and barley straw was respectively, 46, 26 and 25 % slower than that of treated oat hay.

Crude protein (CP) degradation studies suggested that the total degradable CP content of treated wheat, oat and barley straw was water-soluble NPN compounds, highly susceptible to rumen degradation. The remaining CP of the grain straws was virtually undegradable in the rumen, and likely to be of very limited nutritional value.

Ammoniation increased the voluntary intake and the apparent digestibility of OM, DM and the fibre fractions of wheat straw in comparison with untreated and urea-supplemented wheat straw. This trend was unaffected by supplementation with fish and/or maize meal. Although supplementation with fish or maize meal increased the total dry matter intake by 19,4 and 29,5 %, respectively, straw intake was unaffected. Supplementation with fish meal, however, tended to increase straw intake. Both fish and maize meal supplementation increased the apparent digestibility of OM and CP by 7,0-14,4 % and 53,4-101,3 %, respectively. The rumen pH and ammonia levels of the experimental animals were not affected by supplementation.

The apparent DM and OM digestibilities of the diets in which lucerne hay was substituted with 0, 25, 50 and 75 % untreated wheat straw did not differ. The substitution of lucerne hay with ammoniated wheat straw, however, led to an increase in the fibre digestibility of the diets.

The average dry matter intake and growth rate of lambs showed a linear decrease as ammoniated wheat straw increasingly replaced lucerne hay in lamb fattening diets. The feed conversion ratio was also adversely affected by increasing the level of ammoniated wheat straw. The body fat of lambs (determined indirectly by the tritium waterspace technique) on the diet containing only ammoniated wheat straw was 51.6 % lower than that of the lambs on the diet containing lucerne hay only. The apparent digestibility of DM and OM did not differ significantly, but tended to decrease with increased ammoniated wheat straw levels.

The voluntary intake of the pelleted ammoniated wheat straw was 102 % higher than that of the unprocessed (long) ammoniated wheat straw and 63 to 70 % higher than that of chopped or hammermilled ammoniated wheat straw. The ewes on all these diets lost mass during the experiment.

W.5312/05/5/2:

A COMPARISON OF PROCESSED WHEAT, BARLEY, MAIZE AND TRITICALE IN FINISHING DIETS FOR LAMBS. 1985-1987

A.A. Brand

Small grain surpluses in the RSA are causing an increased utilisation of these grains in the livestock feeding industry. The minimal processing of small grains needed to make them suitable for inclusion in sheep diets, as well as the high energy and/or protein value of these grains, may contribute to the greater use of small grains for the feedlotting of lambs.

Enriched barley, wheat, triticale and maize were evaluated in two separate experiments as fattening diets for early weaned (± 10 weeks) S.A. Mutton Merino lambs kept under feedlot conditions. Commercially available lamb creep pellets, obtained from two companies were used as control in the experiments. The in vitro organic matter digestibility (IVOMD) of the small grains was markedly higher than that of the lamb creep pellets, as expected.

In the first experiment, the voluntary intake on the enriched maize was approximately 21 % lower ($P < 0,05$) than that of the other small grains, and 43 % lower ($P < 0,05$) than that of lamb creep pellets.

A similar tendency was obtained in the second experiment, but the only significant ($P < 0,05$) difference was observed on the enriched maize in comparison with lamb creep pellets. The average daily gain of the lambs on the enriched maize was respectively, 54 and 46 % lower ($P < 0,05$) than on the lamb creep pellets in experiments 1 and 2. The average feed conversion ratio (FCR, kg feed/kg gain) of the lambs on the small grains and lamb creep pellets did not differ, but tended to be better than on the enriched maize.

Because of grain surpluses in the world, as well as in the R.S.A., enriched small grains may be used with great economic benefit for the intensive fattening of sheep, provided that it can be obtained at reasonable prices.

W.5312/05, 5, 3:

A COMPARISON OF SUPPLEMENTED AND AMMONIATED OAT GRAIN IN THE FEEDING OF PREGNANT AND LACTATING S.A. MUTTON MERINO EWES. 1986-1988

A.A. Brand

Food scarcity during late summer is a general problem for small stock farmers in the cropping areas of the Winter Rainfall Region. During this period the nutritional requirements of ewes in late pregnancy and lactation increase rapidly, whereas the quality of the stubble pasture decreases.

Untreated, enriched and ammoniated oat grain were supplemented to S.A. Mutton Merino ewes during late pregnancy and early lactation in the 1986 and 1987 lambing seasons. Supplements of 550 and 750 g oat grain per day were fed to the ewes, which were kept in one flock at two small stock units per hectare, from mating in November until three months after lambing. The enrichment of the oat grain included the absorption of urea and minerals, dissolved in water and binding of a buffer and ionophore to the oat grain with molasses. The oat grain was ammoniated by treating it with 3 % anhydrous ammonia in an AN-STRA-VERTER oven for 24 hours at 90 °C.

During late pregnancy there was no significant difference between the masses of the ewes on the different oat grain supplements in both years. During 1987 the ewes on the ammoniated oat grain supplement were on average 5,4 kg heavier during lactation than the ewes getting the untreated oat grain. The ewes on the enriched oat grain were also 4,5 kg heavier at three mass measurings during this lambing season. The average daily gain up to 42 and 100 days of the lambs suckling ewes on ammoniated oat grain

was respectively, 34.4 and 24.6 % greater than that of the lambs of ewes on enriched and untreated oat grain supplements in 1986. Similar results for growth rates up to 100 days were obtained in the 1978 lambing season.

The performances of the lambs on all the treatments could be regarded as satisfactory. Thus untreated oat grain can also be used with great success as a supplement during the summer period. The advantage of ammoniation over enrichment might be attributed to the higher energy content of the ammoniated oat grain. Although ammoniation is more practical and less labour intensive than enrichment with urea and minerals, the treatment costs are higher. As supplements are needed for only four months of the year, the thermo-ammoniation of grain for sheep can be economically justified only if the oven, which requires a large capital investment, can be used for other purposes as well.

• Upgrading

K.5312/07/3/1:

THE RELATIVE ECONOMICAL IMPORTANCE OF CERTAIN CHARACTERISTICS OF
MOHAIR. 1986-1989
A.C. Geyer

The economical principles of supply and demand are mainly responsible in determining the price of mohair. Large price fluctuations normally occur as a result of the influence of the international market. Other factors such as the distance from the market, time of shearing, heterogeneity in the fleece and the incomplete knowledge of market trends also influence the prices. The marketing problem of a farmer is the inability to change the mohair supply. Changing supply takes too long and is inadequate for the consumer.

The main objective of this study was to quantify the relative importance of the different physical properties of mohair. This was necessary for future planning of the marketing strategy and research in the mohair industry.

The sales catalogues for mohair from 1979-1985, as issued by the Mohair Board, were used to determine the different prices for the different types of mohair. The advance payment guides of every season were used to make provision for all the different types of mohair.

To investigate the influence of three physical properties, i.e. fineness, length, style and character on the sale prices, an analyses of variance was applied to the data. Owing to the fact that the mohair prices of adult goats, young goats and kids differ remarkable, the data were analysed according to age groups. In calculating the analyses of variance, the LSML76 computer programme was applied, whereas the GENSTAT statistical analysing programme was used to calculate the different residuals. The validity of the normality assumptions was tested by the BMDP5D computer programme. Where necessary suitable transformations were done with the Box and Fox method.

According to the results, it was clear that fineness was superior to the contribution made to mohair prices. Length of fibre was second, whereas style and character contributed almost nothing to the price of mohair. These results correspond with the present policy, viz that fineness is the most important physical property in the determining of prices.

The facts that high prices were paid for fine mohair and that the demand for fine mohair still increases, emphasize the importance of fineness in mohair.

• Pathology

D.5312/19/1/1:

SMALL STOCK: THE INFLUENCE OF EPERYTHOZOON INFECTION ON THE DEGREE
AND PRESENCE OF ABORTION IN BOER GOATS. 1985-1987
H.H. Barnard

The pathogenicity of *Anaplasma ovis* as a cause of abortion in the pregnant improved Boer goat doe was investigated in a two-phase clinical and hematological survey of twenty Boer goat does kept at the Experimental Farm, Welgevallen, of the University of Stellenbosch during the winter of 1985.

The first phase consisted of the multiplication of the *A. ovis* organism in splenectomized Boer goats. Blood originating from a goat flock in the Little Karoo with a history of abortion was transferred by intravenous injection to five splenectomized Boer goat does. The does were then kept under clinical observation. Rectal temperatures were taken daily and the following hematological values were calculated: red blood cell count, white blood cell count, hematocrit value, hemaglobin value and mean cell volume. Blood smears were made daily and examined.

When the red blood cell count of doe No. 11 reached the level of $5,8 \times 10^2/\text{mm}^3$ and a level of

parasitemia of 6%, 50 ml of her *A. ovis* contaminated blood was transferred intravenously to each of 18 of the pregnant does. They, therefore, received approximately $17,4 \times 10^9$ infected red blood cells. The last two does received their contaminated blood two days later from doe No. 3.

During the second phase a clinical and hematological survey was done on the twenty pregnant and artificially-infected does for a period of 25 days. Examinations were similar to those of the splenectomized does. Some of the does were slaughtered during different stages of the survey and a complete *post-mortem* carried out.

The results were as follows:

1. During the survey period while the artificially contaminated does were confined to their pens and at rest, they showed no obvious signs of the disease. However, when they were forced to walk at approximately 4 km per hour for a distance of 800 metres, the does with the lowest red blood cell counts fatigued fast, showed respiratory distress and refused to walk any further.
2. Body temperature rose by $0,6^\circ\text{C}$ approximately seven days after artificial contamination. In the next four days their temperature showed firstly a decline and then a steady rise to a second peak of $1,1^\circ\text{C}$ above normal on day 14. The average body temperature of the ewes then dropped to a level slightly above the first peak and was maintained at this level for the next seven to nine days. Generally, it was during this latter period that abortion and resorption took place.
3. The red blood cell count of the does started dropping on an average, from the third day after artificial contamination in a step-like pattern but with a partial compensation during the next day. The biggest drop occurred between day 13 and day 16 with an average decline of 25,1%. Red blood cell counts dropped on average from $13,1 \times 10^6/\text{mm}^3$ on day 1 after artificial contamination to $9,8 \times 10^6/\text{mm}^3$ on day 18.
4. The average white blood cell count of the does declined for the first five days after contamination and then stabilised over the next week. A further drop of approximately 14% occurred after day 14.
5. The steplike decline with partial compensation that occurred in the red blood cell count, was also observed in the hematocrit value. The largest decline from 27,9%-21,9% happened between day 13 and day 18.
6. The hemoglobin value of the twenty does dropped for the first time below the normal value of 10 gm% on day 8. The biggest drop from 9,91 gm%-8,36 gm% occurred between day 12 and day 18 and a total drop of 18,1% was recorded during the first 18 days.
7. None of the plasma progesterone levels of any of the does dropped to basal levels of 1 ng/ml or less during the survey of 25 days, except when they aborted or resorbed. It can thus be assumed that they were all pregnant.
8. The average progesterone level declined slowly until day 12 whereafter there was a partial compensatory increase. This rise of 35% corresponds with the second rise in body temperature, and the most rapid decline in red blood cell values. On day 19 after artificial contamination a second drop of 33% was observed with abortions occurring two days later.
9. From the blood smears it was ascertained that transplacental transmission of the *A. ovis* organism from the doe to the unborn lamb occurred before day 10 after artificial contamination. It was also established that the level of parasitemia in the doe can reach a level of 12% and as high as 8% or even higher in the lamb. This leads to the following reactions:
 - (a) the fetuses of less than four weeks development die in utero and are resorbed (2 does),
 - (b) when the fetuses have developed further than four weeks they also die in utero and are aborted three to five days later (6 does),
 - (c) the lambs develop to full-term, but die shortly before or during partus and are then still born (2 does),
 - (d) the lambs develop to full-term and are born with a high level of parasitemia. They die within a few days after birth (1 doe),
 - (e) the lambs are born alive, recover from the *A. ovis* infection after a period of deterioration, and develop to full maturity (1 doe),
 - (f) the lambs are born without any sign of *A. ovis* infection (5 does).
10. The *post-mortems* on slaughtered ewes and on aborted fetuses showed anemic and icteric disease. Fluid accumulated in the body cavities and hollow organs like the lungs. The blood smears of such cases showed a pronounced microcitic hypochromic anemia with a regenerative shift to the left. There are many reticulocytes, basophilic stippling and immature erythrocytes.

The study was aimed at increasing the efficiency of lamb production in a semi-intensive production system through terminal sire cross-breeding. Mature Dorper and Romanov x Dorper ewes (cross-bred) were used. Dorper ewes were mated to Dorper rams and cross-bred ewes to Ile de France rams in a system of three lambing seasons over a period of two years. The cross-bred ewes were superior to the Dorper ewes in terms of conception rate (92,0 versus 82,6 %), fecundity (207,9 versus 134,9 %) and weaning percentage (165,2 versus 107,0 %). Cross-bred ewes had a higher percentage of multiple lambs than Dorper ewes (89,0 versus 58,6 %).

Dorper and cross-bred lambs ($\frac{1}{2}$ Ile de France : $\frac{1}{4}$ Romanov : $\frac{1}{4}$ Dorper), born in a semi-intensive lamb production system, were evaluated under feedlot conditions. Cross-bred lambs had lower growth rates before weaning (219 versus 234 g/day; not significant), but their post-weaning performance was superior to those of the Dorper lambs (254 versus 231 g/day; $P < 0,01$). The Dorper and cross-bred lambs obtained a slaughter mass of 35 kg at a similar age. An autumn or spring lambing season appeared to be more advantageous for lamb growth than a summer lambing season (129,5 versus 131,0 versus 156,7 days of age at slaughter). Single lambs grew faster than twins prior to weaning (245 versus 207 g/day; $P < 0,01$), but the post weaning differences were non-significant. Ram lambs reached the slaughter mass of 35 kg 11,5 days earlier than ewe lambs.

The dressing percentage of Dorper lambs was higher than that of cross-bred lambs (48,7 versus 47,2 %; $P < 0,01$). Cross-bred lambs had shorter but sturdier carcasses than Dorper lambs, as shown in carcass length (597,1 versus 605,2 mm; $P < 0,01$), buttock circumference (589,6 versus 582,0 mm; $P < 0,05$), depth (31,8 versus 30,2 mm; $P < 0,01$) and width of eye muscle (54,2 versus 52,5 mm; $P < 0,01$). Cross-bred lamb carcasses had less fat (ribfat thickness 8,82 versus 10,41 mm and backfat thickness 3,15 versus 3,77 mm; $P < 0,01$) and better fat distribution (buttock: a score of 9,4 versus 8,2 and carcass: a score of 9,4 versus 8,7 out of 10; $P < 0,01$) than Dorper lamb carcasses. Cross-bred lamb carcasses graded superior to the Dorper lamb carcasses (95,2 % versus 51,7 % super grade carcasses).

The influence of tail amputation after birth, and a growth stimulant (Zeranol) implanted at 20 or 60 days of age, on the growth rate of Karakul lambs was investigated. The lambs were slaughtered at a live mass of 23, 27, 31 or 35 kg, respectively

After weaning (60 days) all lambs were fed *ad lib.* in individual pens on a diet containing 10,3 MJ ME per kg dry matter and a crude protein content of 16 %. Mass-measuring was done weekly until slaughter.

Tail amputation had no significant influence ($P > 0,05$) on average daily gain (ADG) and feed conversion, but did affect the fat thickness significantly ($P < 0,05$) in the sacral, lumbar and thoracal regions owing to the relocation of the tail fat. None of these effects resulted in a financial advantage.

The growth stimulant had a significant ($P < 0,05$) effect in all but one of the treatments on the ADG and feed conversion, but did not lead to a higher margin over feed costs.

The highest margin over feed costs per kg carcass was for the 23-kg slaughter group, with a progressive decrease in the margin as slaughter mass increased. With a closer ratio between the price per kg for Lamb 2 versus Super lamb and Lamb 1 the margin above feed costs may increase with an increase in slaughter mass.

Because of the small financial advantage achieved with both tail amputation, and the use of a growth stimulant these treatments must be applied judiciously by the Karakul fat lamb producer. The choice of a slaughter mass must be done with care taking into consideration the price ratio between the various lamb grades.

Non-ruminants

OSTRICHES

• Nutrition

W.5321/05/1/2:

OSTRICHES: THE USE OF METABOLISABLE ENERGY (ME) AS A MEASUREMENT TO EVALUATE FEEDSTUFFS FOR OSTRICHES IN THE KAROO AND ARID AREAS OF THE WINTER RAINFALL REGION. 1985-1988

D. Swart

In order to study energy metabolism in growing ostrich chicks, a series of experiments was designed at the Oudtshoorn Experimental Farm, Oudtshoorn, and the Animal and Dairy Science Research Institute, Irene, to study the digestive strategies and capabilities of ostrich chicks as influenced by live mass, rate of passage and site of digestion. Together with these the digestibility of various fibre constituents such as cell walls (neutral detergent fibre), hemicellulose and cellulose were examined. The production of volatile fatty acids (VFA), the principal non-gaseous end-products of microbial fermentation (fermentative digestion), was also investigated to assess the contribution of microbial digestion to the energy economy of these birds.

An important aspect of this particular study was to determine whether ostriches utilise the end-products of fibre digestion, namely VFA such as acetic acid, efficiently. These studies demonstrated conclusively that the ostrich is a unique avian herbivore with large chambers in the hindgut specialised for fermentative digestion as indicated by large capacity and digesta contents, neutral pH and high concentration of volatile fatty acids (VFA), low lactic and high $\text{NH}_3\text{-N}$.

The long retention time of fibrous feed (40 hours) in the gastro-intestinal tract ensures that fibre is exposed to microbial digestion for extended times, especially allowing efficient degradation of cellulose and hemicellulose. This is supported by the high digestibilities of cell walls (47 %), hemicellulose (66 %) and cellulose (38 %). The presence of a large and complex anaerobic bacterial flora in the hindgut resulted in the production of volatile fatty acids, mainly acetate, the production rates being typical of those reported for the forestomach of ruminants and ruminant-like herbivores.

The absorption and oxidative metabolism of end-products from carbohydrate fermentation, and more specifically cellulose, was conclusively demonstrated to contribute up to 76 % of the daily metabolisable energy intake of the growing ostrich. The results of these experiments provide a fascinating insight into the nutritional ecology of this primitive flightless bird allowing it to survive in the wild under arid conditions with low intake of poor quality feed, and to adapt and thrive under intensive farming conditions.

The possible use of ME to evaluate feedstuffs for ostriches was an initial aim of the metabolism studies. Subsequently the effect of crude fibre on the digestibility of gross energy (GE), energy loss as methane, heat expenditure, and the effect on the efficiency of ME utilisation were investigated. This particular investigation indicated that the addition of dietary energy at an increased concentration of crude fibre (decreasing energy concentration) might have had a depressive effect on ME-utilisation in growing ostriches. Nutrient digestibilities did not only deteriorate, but energy metabolisability also decreased. It seemed that by increasing the crude fibre level of the diet (or decreasing energy concentration), more readily digestible nutrients (e.g. glucose) might have been passed to the hindgut resulting in higher rates of fermentative digestion in the caecum colon with a consequential decrease in energetic efficiency owing to lower utilisation efficiency of VFA energy.

Energy loss as methane was small (1 % of GE), and can be neglected in the determination and application of the ME system for ostriches. However, the use of ME as criterium to evaluate feedstuffs and the formulation of balanced diets for ostrich production requires more research before it can be fully employed. Future research should be aimed at quantifying the influence of crude fibre on ME utilisation over extended ranges of dietary energy concentrations.

Finally an experiment was designed to study patterns of energy intake and the deposition of protein and fat in the growing ostrich chick. The emphasis was on patterns of efficiency of feed utilisation for growth based on the use of longitudinal rather than cross-sectional data. The patterns of body and growth composition of the growing ostrich chick agreed well with that of other growing animals. Although normal growth and thus live mass gain is dependent on a mandatory rate of protein deposition, accompanied by water deposition, it is inevitably subject to an increasing rate of fat storage which apparently commences at the onset of growth. At some stage the deposition of protein and fat will approach equality, subsequently resulting in a change-over of the ratio of protein : fat deposition. This was indicated by a break in the growth curve between 23 and 24 kg live mass of ostrich chicks.

In terms of metabolic body size ($W^{0,75}$) the priority of the allocation of ME to the deposition of body energy in protein or fat undergoes change and is correlated with changes in heat production of the growing animal. This must inevitably alter the maintenance needs of the growing animal. Finally the gross efficiency of the utilisation of ME for the deposition of body energy changes as the apportionment of energy towards protein and fat accretion changes in the growing animal.

• Management

W.5321/41/1/1:

OSTRICHES: THE MICRO-HABITAT OF OSTRICH EGGS DURING NATURAL INCUBATION IN NESTS AND UNDER CONDITIONS OF ARTIFICIAL INCUBATION IN THE KAROO AND ARRID AREAS OF THE WINTER RAINFALL REGION. 1984-1988

D. Swart

The micro-climate of the nest and the rates of egg water loss were studied at weekly intervals throughout the 41-day incubation period in six ostrich nests at the Oudtshoorn Experimental Farm, Oudtshoorn. Overall mean values were a central egg temperature of $34,9^{\circ}\text{C}$ associated with saturated vapor pressure of 42 torr, a mean nest vapor pressure of 11 torr, and an ambient vapor pressure of 8,4 torr. The egg water loss increased from 4 000 to 4 800 mg day^{-1} over the incubation period, and the total water loss was equal to 13,2 % of the initial egg mass of 1 368 g. The mean rate of water loss ($4 403 \text{ mg day}^{-1}$) divided by the water vapor conductance of the shell ($147 \text{ mg day}^{-1} \text{ torr}^{-1}$) equals 30 torr, representing the vapor pressure difference that must have existed between egg and nest air, a value within the normal range of most other bird species ($n = 83$). When this value is added to the nest vapor pressure of 11 torr, it predicts an egg saturation vapor pressure of 41 torr, similar to that derived from the central egg temperature.

Furthermore, a method is described for determining the temperature of fertile and infertile eggs of the ostrich, and the absolute humidity of the nest and ambient air during 41 days of incubation without recourse to direct thermometry or relative humidity sensors. These values are calculated from weekly determinations of mass changes of a diffusion hygrometer made from an ostrich egg-shell, and eggs in the nest, some of whose shell conductance to water vapor had previously been established. During the incubation period the absolute nest humidity remained relatively constant at a mean value of 13,2 torr and was maintained 4,7 torr above the ambient humidity.

The saturation water vapor pressure of fertile (but not of infertile) eggs gradually increased from 41 to 47 torr because of the rise in egg temperature from $34,5\text{--}37,1^{\circ}\text{C}$ at the end of incubation. Infertile eggs remained at $35,0^{\circ}\text{C}$. Because of the increase in saturation vapor pressure of fertile eggs during the last half of incubation, the water vapor pressure difference between the egg and the nest air increased. This change accounted for the proportional change in egg water loss which increased from $4,3\text{--}5,0 \text{ g d}^{-1}$ at the end of 41 days. During the course of incubation the mean water vapor pressure of the eggs ranged from 41,0–47,2 torr at their respective temperatures that varied between $34,5$ and $37,1^{\circ}\text{C}$.

Vapor pressure of the nest air ranged from 12,4–14,6 torr at a mean temperature of $34,4^{\circ}\text{C}$, indicating a mean relative humidity of 33,5 %, a value much lower than the mean reported for other ground nesting species (48 %). Ambient humidity varied between 7,1 and 10,3 torr at a temperature fluctuating between $19,4$ and $36,5^{\circ}\text{C}$.

Considering conditions of artificial incubation for ostrich eggs with a typical water loss rate and egg-shell conductance of $4 507 \text{ mg d}^{-1}$ and $157,3 \text{ mg (d torr)}^{-1}$, respectively and assuming an incubator air temperature of 36°C , the humidity of the incubator air should be 15,9 torr or 36 %. Application of these values in ostrich egg incubators improved the realised hatchability from 50–75 %.

RESOURCE UTILISATION RESEARCH (PASTURE)

VELD

• Ecology

V.5411/27/1/1:

VELD: A STUDY OF THE INFLUENCE OF *RHIGOZUM TRICHOTOMUM* (DRIEDORING) ON OTHER PLANTS IN A NATURAL HABITAT AT THE KARAKUL RESEARCH STATION. 1984-1988

V.5411/27/1/2:

VELD: A STUDY OF THE PHENOLOGICAL DEVELOPMENT AND VEGETATIVE REPRODUCTION OF *RHIGOZUM TRICHOTOMUM* IN A NATURAL HABITAT ON THE KARAKUL RESEARCH STATION AT UPINGTON. 1984-1988

Rhigozum trichotomum is a woody shrub occurring mainly in Griqualand West, Gordonia and the north-western Karoo areas of the RSA. Enchroachment and thickening-up of this plant cause grazing problems on an estimated 5,2 million ha veld. This study was initiated as part of an extensive research programme, examining the biology and ecology of *R. trichotomum* with the aim to formulate management and/or control strategies.

R. trichotomum is a drought-evading plant where dormancy is initiated by moisture stress. The plant has a well-defined pattern of phenological phases with regrowth after a period of drought-induced dormancy. Regeneration is mostly vegetative from a well-developed, extensive root system. Fodder production is low and erratic and especially flowers and capsules are at most opportunistic sources of animal feed.

Rhigozum trichotomum had no effect on absolute grass density. Thickening-up of *R. trichotomum* from 0-1 000 bush equivalents ha⁻¹ suppressed grass production exponentially. Over three seasons grass production was suppressed by respectively, 62; 46 and 93 %, with a calculated decline in grazing capacity of between 43 and 93 %.

Grass extracted soil water mainly to depths of 350 mm, but was able to deplete all the plant available water in a soil profile of 800 mm deep. *R. trichotomum* was also capable of depleting all the plant available water in a 800-mm soil profile. In practice this means competition for soil water after showers of up to 55 mm. In already dense stands, *R. trichotomum* is able to successfully suppress perennial grass establishment and grass production as a result of competition for soil water. Initial drastic control methods will be necessary to restore the natural balance between *R. trichotomum* and grass. Maintenance of a vigorous grass cover may then be able to retard reinfestation.

Relative humidity is the most important environmental factor affecting stomatal conductance of *R. trichotomum* in the veld. The reaction of stomata to changes in relative humidity is regarded as an important physiological adaptation which enables *R. trichotomum* to survive under environmental conditions of relative low humidity and continual droughts. Plant water potential and light intensity also affects stomatal conductance, whereas the effect of temperature is indirect through interaction with relative humidity and light intensity. Air temperature is the most important environmental factor affecting the transpiration rate of *R. trichotomum* in veld, followed by plant water potential and light intensity. Light is the most important factor affecting nett photosynthesis of *R. trichotomum* under veld conditions. Relative humidity, temperature and plant water potential also have significant effects, but these are considered to be mainly indirect as a result of the effect of these factors on stomatal conductance.

A close relationship exists between phenological phase and TNC (total non-structural carbohydrate) content of the plant parts of *R. trichotomum*. The results indicate that TNC is used for leaf growth and flower development with regrowth after dormancy. TNC is high during dormancy. Within two weeks of regrowth after a period of drought-induced dormancy, TNC content declined on average by 53 %, stayed low for a period of five weeks, and was replenished over the following four weeks. In practice it means that the TNC content of *R. trichotomum* is low for a period of five weeks starting at the appearance of flowers.

● Potential studies

T.5411/36/1/1:	THE BIOMASS DYNAMICS OF THE MOST IMPORTANT GRASS SPECIES ON DEBUSH AND NON-DEBUSHED <i>COMBRETUM</i> VELD PASTURES. 1981-1987
T.5411/36/1/2:	PRODUCTION POTENTIAL AND QUALITY OF DEBUSHED AND NON-DEBUSHED <i>COMBRETUM</i> VELD PASTURES. 1981-1987

P.A. Pieterse

Bush clearing usually leads to an increase in DM production of the grass layer, but some authors have found a negative influence on species composition and quality in the long term.

The site on which the trial was done consists of 36 previously erected 0,85-ha paddocks of which half were selected at random and chemically debushed during 1969. A pair of paddocks (bushed/debushed) were used in each growing season (1979/80, 1980/81) of this particular veld experiment.

The five species studied in these trials were *Themeda triandra* and *Heteropogon contortus* as intermediate species, *Digitaria eriantha* var. *pentzii* and *Schmidtia pappophoroides* as forage species and

Eragrostis rigidior as pioneer or non-forage species. During the first year the treatments were: 3, 6, 9 weekly and annual defoliations, at a fixed intensity, on debushed and undisturbed bushveld. During the second year, intensity of defoliation was incorporated as a factor in the treatments and the number of species were reduced to three. All three species were cut at 3, 6, and 0 weekly intervals, but *D. eriantha* var. *pentzii* and *S. pappophoroides* were also defoliated at 80, 120 and 120 mm stubble height and *H. contortus* at 120, 160, and 200 mm.

From the results it is clear that debushing increased DM, crude protein and digestible OM production significantly, without deterioration in the quality of the different species. It was also responsible for a significant increase in the basal cover and a change in the species composition of the grass layer. The soil on the cleared veld had a higher moisture content throughout the year, which resulted in a significant increase in DM production of all the grass species, except *D. eriantha* var. *pentzii*. There also was a shift in the peak of the production curve of *E. rigidior* to an earlier date.

The different species reacted differently to different frequencies of defoliation. It is concluded that defoliation at between six and nine weekly intervals, will result in the best production and retention of vigour. As far as intensity is concerned, the conclusion is that defoliation height should be in the vicinity of 120 mm.

It is also clear that *H. contortus* and *T. triandra*, despite their high production, are not very good forage species in the *Combretum* veld. *D. pentzii* and *S. pappophoroides* on the other hand, produce fodder of good quality, but production per individual tuft is very low. Fortunately, they partially compensate for this by their large numbers per unit area. *E. rigidior* is of quite good quality, and because of its early peak in growth pattern, can produce green fodder of reasonable quality in spring and early summer.

The influence of the availability of N, P and K on the growth and quality of *Digitaria eriantha* var. *eriantha*, was determined in a factorial experiment with four levels of N, four levels of P and three levels of K. The experiment was conducted in sand culture in two-litre plastic pots in a controlled environment. There were five replicates.

When looking at the different elements the highest production was individually achieved with N at 105 mg/l, P at 32 mg/l and K at 150 mg/l. However, the treatment that gave the highest production, was the one where the plants received a solution with N at 105 mg/l, P at 24 mg/l and K at 150 mg/l. It is, however, important to mention that an increase in the P of the solution from 8 mg/l to 32 mg/l only resulted in a 6% increase of production. For K the increase was 13% when K was increased from 50 to 150 mg/l. N also had notable effects on the quality of the forage harvested. Apart from an increase in the N content with increasing levels of N, it also resulted in a decrease in the in vitro digestible organic matter content. N in the solution also had an effect on the P, Ca and Mg content of the forage. P had little effect on quality, but K affected quality especially as far as the mineral content is concerned.

The influences of intensity of defoliation on root growth was studied in root boxes. There were three intensities of defoliation, replicated three times. It was found that although even the most lenient intensity of defoliation (120 mm) effected root growth negatively, root growth was only stopped completely under the most severe defoliation treatment (40 mm).

The influence of intensity and frequency of defoliation on the production and quality of the grass was studied in a factorial experiment on a well-established pasture, on the Highveld Experimental farm of the University of Pretoria. There were four intensities and four frequencies of defoliation. The twenty replicates of each treatment, were in the form of 200 x 300 mm quadrats, placed at positions that gave a 100% basal coverage underneath the quadrat.

Frequency of cutting had the greatest effect on production and quality. Production was highest when cut at twelve weekly intervals, however, cutting at six weekly intervals gave the highest production of crude protein and a high production of in vitro digestible organic matter.

Intensity of cutting did not have a great effect on production and quality, except at the lowest cutting height where production was depressed and at the three weekly interval where production increased with an increase in cutting height.

Production curves for several grass species, as affected by grazing, were determined by means of the difference method, which is a destructive method. Exclosures were used for the protection of certain areas, on which quadrats were cut for the determination of dry matter production. A very good fitting to the Gompertz-curve was obtained with the data.

The tropical grass species in the project reached their highest production at the same time. All the temperate species, with the exception of *L. multiflorum* cultivar Midmar, sown in March 1985 had two periods of peak production. The production curve of the latter differs from the rest as there was no decline in production during the winter months.

These results can be used in fodder flow planning in the ecological area in which the research was done, but because of big differences between these results and those obtained from other regions, it is not advisable to apply it to other agro-ecological regions.

• Management

T.5411/41/1/5:

THE INFLUENCE OF CONTINUOUS GRAZING AND FIXED SEASONAL ROTATIONAL GRAZING SYSTEMS WITH STEERS ON THE WOODY COMPONENT OF THE SOURISH MIXED BUSHVELD. 1986-1987

G.N. Smit

Tree densities, expressed in terms of TE/ha, were quantified for each camp and observation plot, distinguishing between different species and eight height classes. Tree density values were the lowest in those camps that were grazed during the dormant, early growing and late growing seasons, whereas higher TE values were observed in those camps that were grazed for long periods during the growing season. Within-camp differences were recorded which can be attributed to the concentration of the oxen in certain parts of the camps, especially near the waterpoints.

The percentage canopy cover of the tree layer was determined and can be seen as an extension of the number of TE/ha as brought about by the different grazing treatments.

The number of aloes (*Aloe transvaalensis*) was the highest in those camps that were grazed for long periods during the growing season. This species could be considered as an indicator of severe overgrazing.

Grass species and forbs represented in the experimental area were divided into decreaser and increaser groups on the basis of their reaction to grazing. Clear tendencies in reaction to the different grazing treatments were determined.

This is in contrast to the species composition of the tree layer where no clear tendencies could be determined. The increaser IIb-grass group increased in those camps that were grazed for the full growing season or during the main period of the growing season. A clear negative relationship between the increaser IIa- and IIb-grass groups resulted in the increasing of the increaser IIb-group where the increaser IIa-species decreased.

Grass species were divided according to their production potential. The decreaser and increaser IIa-grass groups mainly consisted of species having a high or intermediate production potential, whereas all the species of the increaser IIb-group possessed a low production potential.

Grass production in the canopied sub-habitat was in general higher than in the open sub-habitat. A few grass species preferred the canopied sub-habitat, but owing to the occurrence of *Panicum maximum*, with a high production potential, in mainly the canopied sub-habitat, this sub-habitat is of the utmost importance. The different grazing treatments influenced the sub-habitat preferences of the grass species to a limited extent. Forbs mainly preferred the covered sub-habitat and made a large contribution to the total production of certain camps.

Direct competition effects between the tree layer and the grass layer couldn't be determined, but differences in the species composition of the grass layer were identified as the main reason for the differences in grass production between camps. Grass production was the lowest in those camps that were utilised for long periods during the growing season, because of the high occurrence of species of the increaser IIb-grass which possess a low production potential.

A number of related reactions of the botanical components in reaction to specific grazing treatments were determined, with the result that the non-grass botanical components (trees, aloes and forbs) could also be described in terms of decreasers and increasers. Some of these relationships were linear within the represented value-intervals, whereas others appeared to be non-linear.

Two methods of determining veld condition, based on the occurrence of grass species only, were used to calculate veld condition scores for the different camps. Relationships between these veld condition scores and most of the non-grass botanical components were determined and the relationships were negative in most cases because most of the non-grass botanical components increased in those camps that received the severest grazing treatments.

• Technology

K.5411/52/1/1 and K.5412/52/1/2:

TOWARDS A TECHNIQUE TO MEASURE UTILISATION OF KAROO BUSHES.
1985-1987

F.O. Hobson

The decline in productivity of nutritious grazing for domestic stock in the Karoo has been largely attributed to over-utilisation and selective utilisation of key plant species. While this has been subjectively observed and frequently documented, the virtual absence of tested practical techniques to monitor utilisation of karoo bushes in the short term seriously limits research in this field.

A suitable technique should be both simple and rapid, with minimum degrees of precision and accuracy that enable recommended levels of utilisation (50%), to be reliably distinguished from over-utilisation (70%).

Estimates of utilisation determined from clipped samples of individual plants were more efficient than estimates obtained by clipping quadrats. Owing to the large variation in individual plant masses, approximately 300 plants were required to measure utilisation within minimum levels of precision and accuracy. By separating plants into edible and inedible fractions, approximately 100 plants were required. However, these destructive sampling techniques were laborious and inefficient, thereby emphasising the need for evaluation of non-destructive techniques.

Preliminary studies, using bush height, diameter, area, volume, twig length and twig diameter as parameters to measure utilisation, showed that only area, volume and twig diameter warranted further investigation. Owing to the difficulties encountered in accurately measuring bush volume, vertical bush profiles were evaluated but the rapid deterioration in the correlation with bush mass as utilisation levels increased, ruled out the use of profile areas. In contrast, twig diameter was insensitive to changes in utilisation at levels more lenient than 50%.

Using the descending-point method, it appeared that point-sampling would be the most feasible procedure for objective non-destructive techniques. Because canopy cover was sensitive to changes in utilisation, it appeared that point-sampling should be restricted to within the canopy spread.

Three objective point-sampling techniques, based on percentage cover, percentage edible strikes and percentage twigs grazed, were evaluated together with a subjective ocular-estimation technique.

Because the levels of accuracy of the techniques were similar, ocular-estimation was more economic than the three objective techniques in terms of precision and sample size. In terms of time and effort, the ocular-estimation technique appeared to be at least four times as economic as the objective point-sampling techniques. Proposed guidelines for the use of the ocular-estimation technique are presented in the text.

CULTIVATED PASTURE

• Nutrition

N.5413/05/1/3:

CULTIVATED PASTURES: EFFECT OF VARIOUS LEVELS OF N, P AND K ON THE PRODUCTIVITY OF COASTCROSS II. 1976-1988

P.E. Bartholomew

A replicated 3¹ factorial fertiliser trial was conducted on Coastcross II (also known as K 11) on a soil of the Hutton series at Cedara. The fertiliser levels applied annually to the small plot cutting trial were, 100, 300 and 500 kg N/ha (as LAN), 0, 40 and 80 kg P/ha (as double super-phosphate) and 0, 200 and 400 kg K/ha (as muriate of potash). Phosphorus was applied annually in spring, N was applied in three equal dressings in spring, December and February, and the K was split into two dressings, one in early spring and one in December.

The dry matter yield and response of Coastcross II to increased levels of N, P and K were investigated as well as the distribution of growth rates. The change in nutrient interactions affecting dry matter yields as the seasons progressed, was illustrated and so were the changes in soil nutrients and soil reaction resulting from annual applications of N, P and K.

Yield response of Coastcross II to applied N changed markedly over the seasons. A significant increase in yield from 300-500 kg N/ha was recorded during the last season. It was clear that the soil had reserves of N. The need for a reliable soil N analysis is thus indicated. Increasing the level of applied N had a significant effect on reducing the soil levels of P, K and Ca (through increased yields and thus increased removal of these elements) and increasing the levels of Al and acid saturation, presumably as a result of the reduced pH.

Applications of P affected dry matter yields significantly. Significant increases in soil P and Ca and significant reductions in soil levels of Al and acid saturation were recorded as the level of applied P was increased. Data of the present trial indicate that, for the yields recorded, 40 kg P/ha/annum or a soil test value of 15 ppm P is adequate under a system of complete removal of herbage.

Increasing the level of applied K, over a period of four seasons, indicated a significant yield response from 0-200 kg K/ha annum but no significant benefit from the addition of a further 200 kg K/ha/annum. As the level of applied K was increased the soil K and pH increased, whereas a reduction in soil Ca, Mg, Al and acid saturation was shown. There would be little advantage in exceeding annual applications of 200 kg K/ha annum or a soil test value of 150 ppm K for the levels of production recorded for the present trial.

As growth rate was affected by levels of applied N, P and K (and interactions of these elements) the growth curve (time at which maximum growth occurred) was little affected by fertilisation.

This facet was designed to evaluate a number of potentially suitable legumes for production and persistence under both mowing and grazing conditions when sod-seeded into a *Pennisetum clandestinum* pasture.

Legumes evaluated were: *Trifolium repens*, *T. africanum* var. *glabellum*, *T. semipilosum*, *Desmodium intortorum*, *Glycine wightii*, *Lepedeza cuneata*, *Lotonis bainesii*, *Vicia sativa*, *Macroptillum atropurpureus* cv. *siratiro*, *Medicago sativa*, *Lathyrus silvestris*, *Vigna vexillata*, *Lotus corniculatus*, *Coronilla varia*.

During February 1978 all the above were inoculated, pelleted, and planted into a 3-year-old kikuyu pasture. Lime and phosphate had been applied to reduce the acid saturation to 20% and raise the P level to 30 ppm.

Macroptillum, *T. africanum*, *Lepedeza* and *Glycine* did not germinate. By the end of the second season only *C. varia* persisted.

In February 1983 the entire area was planted to *C. varia*. Broad-leaf weeds proved to be a problem within 8 weeks. A test area outside the trial was sprayed with 2-4 DB. After 14 days no ill-effects were observed. The whole area was then sprayed. Within 4 days of spraying more than 80% of the plants had succumbed. The area was then re-established the following spring and grazed leniently to allow the *C. varia* to become well established. The sward was then subjected to three levels of nitrogen (no N, 150 kg N and 300 kg N/ha/season). Two grazing frequencies, 3 weeks and 6 weeks, were superimposed on the N-level treatments.

Within two three-week grazing cycles (i.e. 6-weeks) the *C. varia* disappeared and never recovered. At the 6 week grazing frequency, the *C. varia* survived for 3 cycles (i.e. 18 weeks) before disappearing and not recovering.

The following conclusions were drawn from this investigation:

1. *Coronilla varia* is not viable within a highly productive kikuyu sward.
2. *C. varia* appears to require at least an 8-week "period of absence" to recover fully before being grazed. Under present economic conditions such a long period of absence is not economical.
3. *C. varia* is sensitive to 2-4DB.
4. A nitrogen contribution in the region of 125 kg N/ha/season appears to have been made by the *C. varia* in the no-nitrogen plots.
5. *C. varia*, although unpalatable, will be eaten by live stock if they are forced to graze it. This could be advantageous if managed prudently by the farmer.

The objective of this investigation was to determine the production and persistence of red clover in a kikuyu pasture with a view to reducing the requirement of nitrogenous fertiliser and improving the quality of the pasture using the morphological stage of the legume as a management factor.

The treatments comprised the following:

1. Two grazing frequencies.
2. Two stocking densities to achieve a leniently and a closely grazed pasture.
3. Three levels of nitrogen 75 kg N, 225 kg N, 375 kg N applied in dressings of 75 kg N per application.

The facet was established in March 1982, the clover being planted in rows one metre apart in a 4-year old kikuyu pasture. Soil nutrient status was brought up to 30 ppm P+ 120 ppm K on soil test. The area was irrigated to ensure good germination and subsequent growth. Irrigation continued on a weekly basis until September 1982 and was then discontinued.

Autumn of 1982/1983 proved to be extremely hot and dry resulting in a c. 80% mortality of the clover component. The clover was not replanted the following season in the hope that it would - if left to grow out - produce sufficient seed to re-establish the stand. However, good rains in early December resulted in such kikuyu growth that the clover was swamped.

During the third season problems were experienced in obtaining sufficient animals of the correct class and type to graze the facet efficiently. By the end of the season the sward had seldom been grazed to the desired intensity - the clover was either under- or over-utilised, thereby confounding the treatments.

As no statistically meaningful data could be collected for analysis, two "trends" became evident:

- 1 If red clover is left to grow out fully (i.e. with 10% of the seed heads drying off) before being leniently grazed (i.e. leaving 40% of the leaf canopy) it can successfully persist in a kikuyu pasture.
- 2 Nitrogen applied in 3 split dressings of 75 kg N per dressing over the season is recommended. Dry matter production levels of the kikuyu are acceptable, whereas the clover is able to compete reasonably successfully with the kikuyu.

The level of pasture management expertise required together with the lower stocking densities necessary to allow the clover to set seed before lenient defoliation, makes this management technique an uneconomical proposition.

• Potential studies

T.5413 36 2 2:

DETERMINATION OF THE GROWTH POTENTIAL OF IRRIGATED PASTURES. 1973-1983 N.F.G. Rethman and H.R.H. Smith

Irrigated Italian Midmar rye grass (*Lolium multiflorum* Lam.) when grown in the environment of the South-eastern Transvaal Highveld has an extensive growing season during which pasture growth rates varies considerably and a large amount of high quality herbage is produced. From a serial cutting trial a growth rate curve was developed for Midmar rye grass. This curve had two maxima, with the maximum growth rate in spring (120 kg DM/ha/day) being more than double that in autumn. The in vitro digestible organic matter content and crude content decreased from 80,6% and 24,1% in autumn to 63,1% and 10,6% respectively, in summer. Crude fibre content increased from 10,1% in autumn to 30,1% in summer.

In a grazing trial, four different utilisation intensity treatments were allocated to Midmar rye grass. The pasture was grazed both continuously and rotationally using variable stocking rates by three sets of weaned lambs in winter, spring, and summer, respectively. Separate linear regressions were determined for each season and grazing method for the relations between available dry matter versus mean stocking rate, available dry matter versus mean average daily gains and stocking rates versus average daily gains.

The results presented in this paper leave no doubt as to the considerable potential for fat lamb production from Midmar Italian rye grass under irrigation in the South-eastern Transvaal. Such pastures are able to support lambs gaining mass at a rate of 150, 200 and 175 g/day at stocking rates of approximately 50, 125 and 80 lambs/ha in winter, spring and summer, respectively.

Consequently they can be used to prepare a sequence of lamb crops for the slaughter market. However, the stocking rate and in turn the amount of available DM/ha, has a profound effect on lamb performance. As stocking rate is increased, so individual lamb performance declines. In practice, therefore, a compromise needs to be reached between the number of animals carried and the level at which each is likely to perform during different periods of the year. The final decision on the stocking rates which should be adopted will, however, depend largely on the particular marketing strategy which is adopted.

Relative responses to the two grazing procedures tested in this study, differed with grazing season. In general, however, rotational grazing allowed higher stocking rates than continuous grazing, particularly during winter and spring. On the other hand, continuous grazing resulted in higher ADG than rotational grazing during spring and summer. The net result was that rotational grazing provided the higher maximum gain/ha in winter, whereas continuous grazing was superior during spring and summer. The implication, therefore, is that by applying rotational grazing during winter and continuous grazing during spring and summer, total gain/ha for all three seasons should be maximised. However, the "put-and-take" grazing technique is not normally feasible in farm practice, so in order to facilitate direct transfer of results to farms, similar research should be conducted under fixed stocking using a range of rotational grazing procedures.

In a preliminary investigation to identify companion legumes best suited to grow in combination with Midmar rye grass, white and red clover were most suited in terms of dry matter yields, crude protein content and the ability to extend the growing season. Serradella and arrow leaf clover were the most suited annual legumes. Nitrogen had a far stronger positive effect on dry matter yields than cutting interval, with the pure rye grass stands responding the most to the addition of nitrogen. The legume component dry matter yields were adversely affected by the addition of nitrogen. The incorporation of legumes into a rye grass sward had the greatest positive effect on dry matter yields and crude protein content and yields when no nitrogen was applied, whereas the total dry matter yields were only slightly reduced when half the maximum amount of nitrogen was applied.

• Management

N.5413/41/1/13:

CHARACTERISATION OF VARIOUS PASTURE SPECIES UNDER DIFFERENT MANAGEMENT SYSTEMS AND STOCKING RATES. 1980-1988

D.I. Bransby and N.M. Tainton

The objectives of the trial were:

- (i) to compare Coastcross II and kikuyu at two levels of nitrogen fertilisation and four stocking rates under continuous grazing,
- (ii) to compare one-year old and two-year old steers at different stocking rates on Coastcross, and
- (iii) to compare rotational and continuous grazing on kikuyu.

The trial was conducted at Ukulinga, the University of Natal's research farm, located in Bioclimate 6.

Results

In general, the relationship between average daily gain (ADG) and stocking rate (S) was well described by linear functions of the form $ADG = a - bS$. The corresponding relationship between gain/ha/day (G) and S is $G = aS - bS^2$, whereas the stocking rate providing for maximum live mass gain per ha (S_{max}) is given by $S_{max} = a/2b$.

Kikuyu vs Coastcross II

At 300 kg N/ha, S_{max} was found to be 11,6 and 11,4 for Coastcross and kikuyu, respectively. At 150 kg N/ha, over five seasons, S_{max} was 10,8 and 7,6 for Coastcross and kikuyu, respectively.

High vs low nitrogen levels

Increasing the level of nitrogen from 150-300 kg N/ha increased S_{max} from 7,6-11,4 for kikuyu. For Coastcross, over three seasons, increasing the level of nitrogen from 150-300 kg N/ha resulted in S_{max} increasing from 10,8-11,6 steers/ha.

One-year-old steers vs two-year-old steers

Comparison between one- and two-year-old steers was made on Coastcross for two seasons. Results from the two seasons differed substantially. For the first year S_{max} was 14,6 and 12,9, with gains per ha of 857 and 846 kg for the one- and two-year-old steers, respectively. For the second year S_{max} was 9,61 and 13,75, with gains per ha of 853 and 1 180 kg for the one- and two-year-old steers, respectively. The year to year variation is difficult to explain. It is possible that the difference in the length of the grazing season, 101 days during the first season and 120 days in the second season, might have favoured the older animals.

Rotational vs continuous grazing on kikuyu (300 kg N/ha)

Comparison of rapid (2 day) and slow (4 day) rotations with a 9-camp system, at a stocking rate of 8,9 steers per ha, provided for live mass gains, at S_{max} , of 721 and 811 kg/ha, compared with 518 kg/ha for continuous grazing.

Comparison of a 12-camp rotation system and continuous grazing indicated a 17 % mass gain per ha advantage of rotational grazing over continuous grazing.

V.5413/41/1/1:

CULTIVATED PASTURES: COMPARISON OF VELD AND VELD IN COMBINATION WITH CULTIVATED PASTURE IN TERMS OF BEEF PRODUCTION AT ARMOEDSVLAKTE.
1979-1982

L.G. du Pisani

Two beef production systems comprising of veld alone and veld in combination with *Anthephora pubescens* (11,8 % of total area) were compared during 1979 to 1982. An optimum stocking rate of 2,3 ha/MLU was obtained on the *Anthephora*-pasture (475 mm rainfall, fertilisation: 22,6 kg P and 28 kg N/ha every four

years), as compared to 7 ha/MLU on veld in climax condition. At these stocking rates optimum veld condition was maintained, whereas animal production (weaning percentage and mass) did not differ between the two systems.

On veld alone, a gross margin of R16,10/ha was realised, compared to an estimated gross margin of R23,95/ha on *Anthephora* pasture only (without considering establishing costs). These results indicate a margin of 12,4 years on climax veld (7 ha/MLU) and 6,1 years on pioneer veld (14 ha/MLU) to cover establishment costs by means of the higher gross margin released from *Anthephora* pasture.

LUCERNE

• Pests

V.5414/20, 1/1:

LUCERNE: INVESTIGATION ON THE OCCURRENCE AND DISTRIBUTION OF THE WHITE FRINGED BEETLE ON LUCERNE IN THE LOWER ORANGE RIVER IRRIGATION AREA. 1985-1989

J. de Jager

The white fringed beetle, *Graphodgnathus leucoloma*, attacks lucerne in the Lower Orange River irrigation area. At present the geographical distributors of the insect extends from Groblershoop in the east to the Augrabies Falls in the west. During its life cycle of 12-15 months, seven larval instars occur over a period of 9-12 months. During this period severe damage is caused by the larvae to the roots of lucerne.

Owing to the fact that the flow of the river is from east to west and since adult beetles are dispersed by water in this area, the distribution of adult beetles by means of the river or canals was found to be more towards the western parts of the area.

Since generations overlap, larvae were found throughout the year at different depth intervals in the soil. Although most of the larvae were found in the top 300 mm, the vertical distribution of larvae in the soil extended to a depth of 750 mm. In the period December to March most of the larvae occurred deeper than 150 mm in the soil. During larval development young larvae tend to occur relative deep in the soil, whereas older larvae were found in the shallow soil layers. The last larval instar (instar 7) occurred exclusively in the top 150 mm.

As an alternative for the head capsule width, characters such as head capsule length, size of clypeus, mass, length and diameter of larvae are described in this report which makes it possible to determine different instars. In the absence of a host plant young larvae (instar 2) are able to survive in the soil for a period of 7-14 days, whereas older larvae (instar 5 and 6) can survive for a period varying from 31-62 days.

The occurrence of white fringed beetle larvae on lucerne, even at low infestation rates, have the potential to cause significant yield losses within one season. Root losses of up to 80% may occur at high infestation rates. Owing to the fact that lucerne is a perennial crop and since a succession of generations of the pest occurs on lucerne, the possibility exists that high infestation rates may cause a lucerne field to become unproductive in the second year after establishment.

Pupae were found in the soil in the top 150 mm. Adults occurred from the end of January to February and from April to the middle of June. The peak occurrence of adults was during February. Temperature plays an important role in the duration of the pupal and adult stages. Fecundity of adults seems likely to depend on the protein content of the host plant. The higher the protein content of the leaves of the host plant, the more eggs are produced. A high fecundity rate occurred with lucerne as host plant, whereas low fecundity occurred in the case of sultana and wheat.

The population density of the insect increases rapidly from one season to the other. The larval population increased from 20 larvae per square metre during November 1985 to 128 larvae per square metre during November 1987. At the same time the adult population density increased from 15 adults sampled in pit traps during February 1986 to 170 adults sampled during February 1987.

The white fringed beetle is a serious threat to the lucerne industry in the Lower Orange River irrigation area.

• Crop science

H.5414/30/2/1:

LUCERNE: THE INFLUENCE OF CLIPPING FREQUENCY ON THE PRODUCTION, GROWTH VIGOUR AND QUALITY OF LUCERNE (*MEDICAGO SATIVA*). 1984-1987

C.S. Dannhauser, R.H. Drewes and Erika A. van Zyl

One of the measures that can be taken to prevent bloat of animals on lucerne, is to allow it to reach the flowering stage before it is grazed by either cattle or sheep. The generally recommended stage for cutting hay

is at 10 % flowering, whereas in practice, many lands are grazed particularly when the lucerne is relatively young.

This preliminary experiment was conducted to evaluate the effect of defoliation on SA Standard and CUF 101 lucerne cultivars by cutting at progressively more mature stages of growth and regrowth over the growing season. The respective stages were pre-flowering; 10 % flowering; full-flowering and post-flowering. The effect of these treatments was measured in terms of herbage yield and by determining the in vitro digestibility and the N content of the herbage. After applying the treatments for three years, the regrowth potential was determined during spring.

In general there were no significant differences in yield between the two cultivars. As expected, the herbage yield increased with increasing maturity, whilst the crude protein and in vitro digestibility decreased progressively, although never reaching a figure of less than 63,2 % digestibility or lower than 17,2 % in protein. The regrowth potential, however, was higher the more mature the stage of cutting.

Allowing the lucerne to reach at least the full-flowering stage before being utilised, is not only a useful precaution against bloat, but can contribute substantially towards the longevity of the lucerne. The chemical determinations also indicate a potentially acceptable quality even when the lucerne has reached maturity.

AGRICULTURAL PRODUCTION ECONOMY RESEARCH

Macro resource economy

PRODUCTION FACTOR STUDIES

● *Production economics*

PE.5611/48/2/1: DETERMINING THE VALUE OF AGRICULTURAL LAND IN THE R.S.A. 1980-1986
B.D.T. Janse van Rensburg

Land values and land prices were determined by use of different methods in the Highveld Region. Three subregions were individually identified, namely the North-western Free State, Transvaal Highveld and the Western Transvaal.

Divergent results were obtained and differences occurred between the results of the income capitalisation approach to value and the market comparison method.

With the differences that occurred between the values of the two methods, it seems that non-monetary factors are playing a significant role in the determining of land values. The investment motive is also likely to be a factor of great importance.

Capitalising of rental tariffs indicates a value that is more in line with the values that were obtained with the market comparison method.

The use of the income capitalisation approach to value will depend on the motives of the prospective land buyers.

PE.5611/48/2/2: DETERMINING RENTAL TARIFFS AND PARAMETERS FOR REALISTIC RENTAL
TARIFFS OF AGRICULTURAL LAND. 1980-1983
A. Poray

Problems of rental payments for agricultural land are regularly discussed overseas. Research on this topic in South Africa with the help of mail questionnaires has given promising results.

Generally a large percentage of rental agreements are subject to two influences, namely family or special arrangements and long-term contracts at fixed cash payments. Although the frequency varies from region to region, these arrangements tend to lead to a lower rental payment as what can commercially be expected.

Important parameters in the determination of short-term rental payments are the productivity of land and the degree of local competition for land use. Both of these factors depend to a certain degree on rainfall, especially in extensive grazing areas.

Data which were collected indicate that normal market-related rental payments are generally low in comparison with land values or in comparison with interest on borrowed capital. The average rental rate for all regions is calculated at 3,7 % for 1982. However, where there is a large degree of competition - for

example in tender situations - the result is a rental tariff that is high in comparison with the productive value of land.

STRUCTURAL STUDIES

• *Production economics*

PE.5612/48/1/5:

INPUT-OUTPUT RELATIONSHIPS AND EXPECTED ECONOMIC RETURNS IN CROP PRODUCTION WITH VARIABLE WATER SUPPLY. 1986-1988

T. Virag

Variable water availability necessitates adjustments in irrigation practice. Relationships between water supply and crop yields are, therefore, important.

Available models to predict water-yield relationships were compared. Best results were obtained with the Wageningen method for expected yields, and the Penman and Pan methods for water requirements. A simulation model was developed for four wheat cultivars and three planting dates at Vaalharts.

Expected yields with adequate and restricted water supply, and economic returns were computed. Optimum adjustment to water restrictions could be determined in this way. Effects are less serious with water reductions in the head development and yield formation growth stages. In these stages, a 100-mm reduction in water causes only modest yield and profit reductions. Reductions of up to 250 mm can also be acceptable if water limitations follow simulated irrigation schedules.

More and better micro-level data are urgently needed for future research and planning needs.

RESOURCE CONSERVATION

Planning of areas

FARM PLANNING

• *Agrohydrology*

T.5831/34/1/6:

RUN-OFF CONTROL IN THE KLEIN KOMATI AREA OF THE SOUTH-EASTERN TRANSVAAL. 1975-1988

J.C. Mouton

The aim of this facet was the design of a water run-off control system and the practical application thereof in this specific target area.

The method used to achieve this aim is set out in the "Water Pert" document drafted by the Transvaal Region.

The soil association map and the hydrological plan were successfully completed, but the application of the plan was only partially successful.

We would recommend that the facet be terminated as water run-off control on the steep slopes (4-6 %) has been largely effectively applied so that the time and energy of officials can be used more effectively in other areas where a greater need for water run-off control exists at present.

ENTREPRENEUR DEVELOPMENT

PROGRAMMED EXTENSION

Resource utilisation

STOCK AND GAME FARMING

• Persuasion

N.6211/39/1/2:

THE PROMOTION OF FODDER PLANNING EFFICIENCY TO MEET DRY MATTER
REQUIREMENTS OF DAIRY CATTLE IN THE HOWICK EXTENSION WARD. 1987
R.M. Webster

The Howick Extension Office initiated a programme in late 1981 with the objective to enlighten dairy farmers in the Howick Extension Ward in the technique of fodder planning so that 50 % of them will, within a period of 5 years, produce sufficient fodder of acceptable quality, to meet herd and fodder bank requirements.

Work procedure

The strategy of the programme was to deal with the majority of dairy farmers in the area, which was divided into 3 subareas. Both group educational and personal extension techniques were employed, with participants being encouraged to develop their own plans after attending instruction courses on feed and fodder planning, as well as resource utilisation planning. Visits to well-planned farms, newsletters and personal visitations were all techniques used to bring about dissatisfaction with their present situation and a striving towards improvement.

The programme of activities was spread over five years with the final analysis of results being carried out in 1986/87. In order to assess if farmers had achieved the desired state of forage planning and production, four different ratios were developed - measured as tons of dry matter produced on the farm, over tons of dry matter consumed by the dairy herd.

A ratio of 1:4 and above was considered to be adequate to provide for wastage and a good fodder bank. A ratio of 0:9 and below was considered to be inadequate to supply sufficient forage for the dairy herd, let alone allowing for wastage and forage reserves. Intermediate ratios provided for intermediate situations.

The results of the programme were most encouraging, and were measured with 36 dairy farmers who had initially filled in fodder questionnaires and had remained in the area and in dairy farming. Because the initial situation on these farms had been carefully recorded, it was possible to accurately assess changes made over the period.

The following results were realised:

1. Ratio of dry matter produced/to dry, matter consumed.

Meeting requirements with adequate reserves		
Before programme	(1982)	19 %
After programme	(1987)	63 %
Not able to meet requirements		
Before programme	(1982)	40 %
After programme	(1987)	16 %

2. The number of litres per cow had increased amongst the group with 36 % of the farmers showing an increase of 10 % or more.
3. The number of actual fodder units carried, had increased amongst the group with 51 % of the farmers increasing their number of fodder units (stock) by more than 10 %.

4. The area of summer pasturage (mainly kikuyu) had greatly increased during the period, with 77 % of the farmers increasing their area by more than 10 % grown under these pastures.
5. A number of programme participants had been persuaded against too heavy a reliance on cool season dryland pastures, and 33 % of the farmers had reduced their areas during the programme period.
6. Irrigated cool season pastures had greatly increased over the period, with 63 % of the participants increasing their areas.
7. Dryland forage crops had been increased on certain farms (61 % of participants) whereas others had managed to decrease their areas because of increased irrigation (16 %).

It can be accepted that the Fodder Flow Planning Programme initiated by the Howick Office in 1982, achieved the stated objective and that future activity in the area should now be concentrated on aspects of forage management.

Conclusion

The results of the persuasion programme amongst dairy farmers in the Howick Extension Ward proved that the objectives of the programme were attained.

By teaching the farmers the basic principles of sound fodder flow planning, it was possible to improve the level of fodder flow planning as practised by the target farmers to a significant extent. As an example, the 19 % of farmers that had sufficient fodder reserves at the start of the programme were increased during the course of the programme to a level of 63 % of the target group having sufficient reserves.

It can thus be concluded that the programme was a success and that the dairy industry in the Natal Midlands had benefitted from this extension effort.

N.6211 39.1/5:

PROMOTION OF CULTIVATED PASTURES IN THE UNDERBERG EXTENSION WARD.
1985-1988

C.M. Green

The project was aimed at promotion of improved management techniques for cultivated pastures by means of group education, farm tours and advisory visits, with a community of 140 farmers and two study groups as audience.

The two study groups consisted of an "older" group, i.e. farmers who have had a number of years of experience and who were members of previous study groups, and a younger more inexperienced group with a very keen interest.

A sequence of lectures, to be offered in conjunction with farm visits and practical demonstrations, were developed with activities timed to take place just prior to the time the different farming operations normally occur.

During the first year 15 educational activities were organised for the two groups dealing with topics such as seedbed preparation, fertilisation, selection of soils for pastures, irrigation and the economic aspects of pasture production, followed up by nine activities in the second year and two in the third year, with the reduced input being due to study commitments.

Trials to determine the dry matter production of irrigated rye grass and small plot demonstration trials at the extension office to introduce farmers to 15 different grasses and 9 different legumes, created great interest.

Individual farm advisory visits and short relevant articles published in the local press were used to back up group educational activities.

While no statistical evaluation was made, evaluation by means of observations and enquiries indicated that a greater understanding of the management and utilisation of pasture was achieved with much of the acquired knowledge being brought into practice. Yields of 14 tons per hectare of dry matter from irrigated Midmar rye grass were obtained in both the dairy and beef systems utilising pastures.

N.6211.39 4 1:

THE PROMOTION OF DAIRY FARMING IN THE IXOPO EXTENSION WARD. 1985-1988

M.J. Pereira da Conceicao

The project to promote improved dairy farming in the Ixopo Extension Ward was aimed at improving systems of rearing and selecting dairy heifers and at improving the feeding of dairy cows.

The target audience for the project comprised all the dairy producers in the Ixopo Ward divided into three community groups, namely, Donnybrook, Creighton and Ixopo Highflats.

A total of 9 discussion group meetings and 9 demonstrations were held during the two-year period. Systems used by farmers to rear dairy heifers were analysed and proposals for the most efficient system formulated. These proposals were made available to other farmers in the form of a manual. An average of 75% of the target audience attended the group discussions. The programme resulted in an estimated 20% improvement in heifer rearing systems.

The computerised Cedara Dairy Feeding Programme was used to make 265 recommendations for the feeding of dairy cows, whereas a further 75 individual ration formulations were compiled. Four farmer days, being attended by an average of 65% of the dairy farmers, were held to promote more economical dairy production. Through the use of the Cedara Feeding Programme attention was also focussed upon herd fertility. A comparative analysis indicated an increase of 33% in milk production and a 25% increase in herd fertility of the herds surveyed.

SCIENTIFIC ARTICLES
WETENSKAPLIKE ARTIKELS

PLANT PRODUCTION PROMOTION PLANTPRODUKSIEBEVORDERING

AGRONOMY RESEARCH/AKKERBOUNAVORSING

Summer grain/Somergraan

MAIZE/MIELIES

• Nutrition/Voeding

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- DU TOIT, W., 1989. Die invloed van bemestingplasing op wortelontwikkeling van mielies. *South African Journal of Plant and Soil* 6(2), 142-143.
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- *Pathology/ Patologie*

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PROTEAS

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WEEDS/ONKRUIDE

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- *Ecology/Ekologie*

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- *Microbiology/Mikrobiologie*

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ANIMAL PRODUCTION PROMOTION DIEREPRODUKSIEBEVORDERING

ANIMAL PRODUCTION AND ANIMAL PRODUCTS RESEARCH DIEREPRODUKSIE- EN DIEREPRODUKTENAVORSING

Animal production/Diereproduksie

BEEF CATTLE/VLEISBEESTE

- *Upgrading/Veredeling*

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- *Nutrition/Voeding*

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- *Genetics/Genetika*

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WOOLLED SHEEP/WOLSKAPE

- *Upgrading/Veredeling*

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HORSES/PERDE

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• *Nutrition/Voeding*

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OTHER ANIMALS/ANDER DIERE

• *Anatomy/Anatomie*

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Animal products/Diereprodukte

MEAT/VLEIS

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MILK/MELK

• *Microbiology/Mikrobiologie*

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• *Chemistry/Chemie*

- VENTER, B.G., VAN RENSBURG, L. & DE LANGE, D.J., 1989. High performance liquid chromatographical separation and quantification of α -lactalbumin and β -lactoglobulin genetic variants A and B from cow's milk. *South African Journal of Dairy Science* 21, 41-44.

DAIRY PRODUCTS/SUIWELPRODUKTE

• *Microbiology/Mikrobiologie*

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• *Norm studies/Normstudies*

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• *Technology/Tegnologie*

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• *Chemistry/Chemie*

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Supporting animal research
Ondersteunende veekundige navorsing

ANIMALS/DIERE

• *Anatomy/Anatomie*

- VAN DER WALT, J.G., MEYER, J.H.F. & VAN RENSBURG, I.B.J., 1989. Ileorectal anastomosis in sheep: Effect on feed intake, and on digestive tract anatomy and blood flow patterns. *Proceedings of*

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- *Reproduction/ Reproduksie*

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VIRUSES/VIRUSSE

• Pathology/Patologie

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PROTOZOA/PROTOSOA

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Molekulêre biologiese ondersoeke

MACRO-MOLECULES/MAKROMOLEKULE

• Protozoology/Protosoölogie

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AGRICULTURAL RESOURCE UTILISATION LANDBOUHULPBRONBENUTTING

RESOURCE RESEARCH/HULPBRONNAVORSING

Primary resources/Primêre hulpbronne

SOIL/GROND

• Ecology/Ekologie

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• Remote sensing application/Afstandwaarnemingstoepassing

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- *Soil science/Grondkunde*

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- *Meteorology/Weerkunde*

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Surveys and demarcation/Opnames en afbakening

SOIL SURVEYS/GRONDOPNAMES

- *Soil science/Grondkunde*

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Irrigation and drainage research

Besproeiings- en dreineringsnavorsing

IRRIGATION PLANNING/BESPROEIINGSBEPLANNING

- *Evaluation/Evaluasie*

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RESOURCE UTILISATION RESEARCH (CROPS)

HULPBRONBENUTTINGSNAVORSING (GEWASSE)

Field crops/Landgewasse

SUMMER GRAIN/SOMERGRAAN

- *Nutrition/Voeding*

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- *Pathology/Patologie*

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- *Chemical control/Chemiese beheer*

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AGRONOMY RESEARCH/AKKERBOUNAVORSING

Summer grain/Somergraan

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- GG.2121/19/1/5: Chemical control of root disease in wheat. 1982. E.M. Smith

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- GG.2121/20/1/3: Seed treatment with systemic insecticides for the chemical control of the Russian wheat aphid, *Diuraphis noxia*. 1980. F. du Toit
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- GG.2121/30/3/3: Determination of the optimum planting date and sowing rate of wheat cultivars under irrigation. 1983. G.J. Kotze
- GG.2121/30/4/1: The influence of soil cultivation methods on the production ability of soil with wheat in the summer rainfall region. 1982. H.A. Smit
- GG.2121/30/4/2: The influence of stubble mulching on grain yield of wheat in the summer rainfall area. 1982. H.A. Smit
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• *Chemistry/Chemie*

- GG.2121/53/1/1: Evaluation and refinement of routine quality analytical procedures on wheat. 1976. H.A. van Niekerk

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• Upgrading/ Veredeling

GG.2122/07/1/1: The evaluation of elite newly developed and introduced cultivars. 1976. C. Bothma

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DURUM

• Nutrition/ Voeding

GG.2123/05/1/1: Effect of nitrogen fertilisation on the production and quality of durum wheat under irrigation. 1982. W.H. Killian

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GG.2123/07/1/1: The evaluation of elite newly developed and imported durum lines. 1976. H.A. van Niekerk

GG.2123/07/2/1: The evaluation of durum germ plasm. 1981. I.B.J. Smit

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• Physiology/ Fisiologie

GG.2124/03/1/1: Determination of factors which cause black-end coloration to barley in the winter rainfall area. 1982. E.J.G. Brand

• Upgrading/ Veredeling

GG.2124/07/1/1: The breeding of barley and evaluation of elite newly developed and imported cultivars. 1976. P.B. le Grange

GG.2124/07/2/1: The evaluation of barley germ plasm. 1981. I.B.J. Smit

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- GG.2124/30/1/2: Seed multiplication of the elite barley lines and cultivars in the summer rainfall area. 1982. G.D. Joubert
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- GG.2124/30/3/1: Leaf number/apex development stage relationship of barley in the winter rainfall area as influenced by chemical weedicides. 1982. H.A. Smit
- GG.2124/30/3/2: Phytotoxicity of wild oat herbicides on barley in the winter rainfall area. 1982. H.A. Smit
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RYE/ROG

• *Upgrading/Veredeling*

- GG.2125/07/1/1: The evaluation of elite newly bred and imported rye lines. 1976. H.A. van Niekerk
- GG.2125/07/2/1: The evaluation of germ plasm. 1981. I.B.J. Smit
- GG.2125/07/2/2: The upkeep of unique rye germ plasm. 1981. M.T. Aartsma
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OATS/HAWER

• *Upgrading/Veredeling*

- GG.2126/07/1/1: The evaluation of elite newly developed oat lines and introductions. 1976. M.T. Aartsma
- GG.2126/07/2/1: The evaluation of oat germ plasm. 1981. I.B.J. Smit
- GG.2126/07/2/2: The upkeep of unique oat germ plasm. 1981. M.T. Aartsma
- GG.2126/07/2/3: The development of a computerised database for oat germ plasm. 1983. M.T. Aartsma

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Protein and oil seeds/Proteien- en oliesade

GROUNDNUTS/GRONDBONE

• Physiology/Fisiologie

- GG.2131/03/1/1: Groundnuts: partitioning analysis. 1981. J. Dreyer
- GG.2131/03/2/1: The influence of varying temperatures on the gynophore and pod set of groundnuts. 1983. J. Dreyer

• Nutrition/Voeding

- GG.2131/05/1/1: NPK fertiliser studies with groundnuts. 1983. H.L. Loubser
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- GG.2131/05/1/3: Calcium fertilisation of groundnuts. 1985. C.J. Swanevelder
- GG.2131/05/1/4: The influence of nitrogen fertilisation and daminozide on the production of runner type groundnuts. 1985. C.J. Swanevelder
- GG.2131/05/1/5: Foliar application of seaweed extract on groundnuts. 1985. C.J. Swanevelder

• Upgrading/Veredelings

- GG.2131/07/1/1: Evaluation of introductions and breeding parents of groundnuts. 1974. P.J.A. van der Merwe
- GG.2131/07/1/2: The improvement of groundnuts for dryland conditions. 1974. P.J.A. van der Merwe
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- GG.2131/07/1/5: Studying and development of anther culture techniques in aid of development of new groundnut cultivars. 1986. P.C.W. van der Walt

• Pathology/Patologie

- GG.2131/19/1/1: Fusarium diseases of dryland cultivated groundnuts. 1985. S.H. Swart
- GG.2131/19/2/1: *Macrophomina* infections on groundnuts. 1985. E.L. Holtzhausen
- GG.2131/19/3/1: The influence of groundnut root and pod exudates on *Chalara elegans*. 1984. J.R. Anderson
- GG.2131/19/3/2: The influence of groundnut rhizosphere micro-organisms in controlling/stimulating *Chalara elegans* infestation. 1984. J.R. Anderson
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- GG.2131/19/3/4: Method of entry of *Chalara elegans* into groundnut tissue. 1984. J.R. Anderson
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- GG.2131/19/3/7: Laboratory and greenhouse preliminary screens on groundnuts for biocides active against *Chalara elegans*. 1984. J.R. Anderson
- GG.2131/19/3/8: Developing of laboratory-greenhouse method for testing groundnut genotypes for resistance to *Chalara elegans*. 1983. B.L. Jones
- GG.2131/19/3/9: The use of crop rotations in controlling *Chalara elegans* in groundnuts. 1983. B.L. Jones
- GG.2131/19/3/10: Survey of naturally occurring *Chalara elegans* in the groundnut production areas of the RSA. 1982. B.L. Jones

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- GG.2131/20/1/1: *Hilda patruelis* and mould on groundnuts. 1984. C.J. Swanevelder
 GG.2131/20/2/1: A survey of the incidence of plant parasitic nematodes on groundnuts in South Africa. 1987. C. Bolton
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• *Integrated control/Geïntegreerde beheer*

- GG.2131/23/1/1: Competition components of weeds in groundnuts. 1987. A.P.J. de Beer

• *Crop science/Gewaskunde*

- GG.2131/30/1/1: Groundnut cultivar evaluation in different production areas. 1977. C.J. Swanevelder
 GG.2131/30/2/2: Ridge planting of groundnuts for limiting black hull. 1982. J. Dreyer
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 GG.2131/30/3/1: The influence of planting date on runner type groundnuts. 1985. C.J. Swanevelder
 GG.2131/30/4/1: Determining the effect of nut grass, *Cyperus* spp. on the yield of groundnuts. 1982. A.P.J. de Beer
 GG.2131/30/4/2: The effect of Dinitroanilien herbicide on the growth and development of the runner type groundnuts. 1983. A.P.J. de Beer
 GG.2131/30/5/1: The influence of mulching on mould contamination of groundnuts. 1984. C.J. Swanevelder
 GG.2131/30/8/1: Studies on spacing with newly released groundnut cultivars. 1985. C.J. Swanevelder

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- GG.2131/31/1/1: Crop factor determination for groundnuts under irrigation. 1988. W. Jansen
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SUNFLOWERS/SONNEBLOMME

• *Nutrition/Voeding*

- GG.2132/05/1/4: The effect of mycorrhiza on the utilisation of phosphorus by sunflowers. 1985. H.L. Loubser
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• *Upgrading/Veredeling*

- GG.2132/07/1/1: Introduction and evaluation of sunflower lines for use in a breeding programme. 1974. W.J. Vermeulen
- GG.2132/07/1/2: The breeding of sunflower restorer lines and composites for utilisation in hybrid breeding. 1974. B.C. Greyling
- GG.2132/07/1/3: The breeding of sunflower A/B lines and composites for utilisation in hybrid breeding. 1974. W.J. Vermeulen

• *Pathology/Patologie*

- GG.2132/19/1/1: *Macrophomina* infections of sunflower. 1985. E.L. Holtzhausen

• *Crop science/Gewaskunde*

- GG.2132/30/1/1: Evaluation of sunflower cultivars in different production areas. 1978. H.L. Loubser
- GG.2132/30/1/2: The ability of sunflower cultivars to compensate for low plant populations. 1983. H.L. Loubser
- GG.2132/30/1/5: Self-pollination and self-compatibility of sunflower cultivars. 1985. E.B. Birch
- GG.2132/30/1/6: Tolerance of sunflower cultivars to Al toxicity. 1983. E.B. Birch
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- GG.2132/30/2/5: Run-off on sunflower soils. 1985. E.B. Birch
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• *Modelling/Modellerling*

- GG.2132/42/1/1: Predicting the effect of nitrogen fertilisation and moisture supply on the yield of sunflowers. 1985. H.L. Loubser

SOYBEANS/SOJABONE

• *Physiology/Fisiologie*

- GG.2133/03/1/2: Interaction between yield components and interplant competition ofs. 1985. M.A. Smit
- GG.2133/03/1/3: Identification of soybeans on a biochemical level. 1987. C. Sullivan

• *Nutrition/Voeding*

- GG.2133/05/1/1: The interaction of lime on nitrogen, phosphorus and potassium fertilisation on soybeans. 1983. J. Chapman

• *Upgrading/Veredeling*

- GG.2133/07/1/1: Evaluation of soybean lines/introductions for use as commercial cultivars and/or as parents in a breeding programme. 1983. T.E.M. Odendaal

GG.2133/07/1/2: The selection and generation of segregating material. 1984. T.E.M. Odendaal

• *Integrated control/ Geïntegreerde beheer*

GG.2133/23/1/1: The specific susceptibility of different soybean cultivars to herbicides. 1987. T.H. Bantjes

• *Crop science/ Gewaskunde*

- GG.2133/30/1/1: Evaluation of soybean cultivars in different production areas. 1978. J.N.H. Lemmer
- GG.2133/30/1/2: The influence of plant population and row spacing on different soybean cultivars. 1984. J.N.H. Lemmer
- GG.2133/30/1/3: Tolerance of soybean, sunflower and dry bean cultivars to Al toxicity. 1982. M.A. Smit
- GG.2133/30/1/4: Genotype x environment interactions on yield tests and the application to a soybean breeding programme. 1984. T.E.M. Odendaal
- GG.2133/30/2/1: Basin tillage in soybean production. 1984. E.B. Birch

DRY BEANS/DROëBONE

• *Nutrition/ Voeding*

GG.2134/05/1/1: The effect of nitrogen application levels at different growth stages of dry beans. 1983. A.J. Liebenberg

• *Upgrading/ Veredeling*

- GG.2134/07/1/1: The evaluation of dry bean introductions. 1970. W.J. Vermeulen
- GG.2134/07/1/2: The breeding of dry beans for canning purposes. 1970. W.J. Vermeulen
- GG.2134/07/1/3: The breeding of dry beans for the packaging trade. 1983. B.R. Edington

• *Pathology/ Patologie*

- GG.2134/19/1/1: The production of disease-free dry bean (*Phaseolus vulgaris*) seed at Lutzville and Burgershall. 1977. A.J. Liebenberg
- GG.2134/19/1/2: The production of disease-free dry bean (*Phaseolus coccineus*) seed. 1984. A.J. Liebenberg
- GG.2134/19/2/1: Survey of fungal diseases on dry bean roots in the summer rainfall regions of South Africa. 1985. S.H. Swart
- GG.2134/19/2/2: Survey of fungal diseases on the pods of dry beans in the summer rainfall regions of South Africa. 1985. S.H. Swart
- GG.2134/19/2/3: Survey of fungal diseases on dry bean leaves in the summer rainfall regions of South Africa. 1985. S.H. Swart
- GG.2134/19/3/1: Macrophomina infections of dry beans. 1985. E.L. Holtzhausen
- GG.2134/19/4/1: Halo blight of dry beans. 1985. L. van der Walt
- GG.2134/19/4/2: Common blight (*Xanthomonas phaseoli*) of dry beans. 1985. L. van der Walt

• *Crop science/ Gewaskunde*

- GG.2134/30/1/1: The evaluation of dry bean cultivars in different production areas. 1983. A.J. Liebenberg
- GG.2134/30/1/2: The determination of the compensation ability of dry bean cultivars under varying plant densities. 1983. A.J. Liebenberg

- GG.2134/30/1/3: The evaluation of dry bean cultivars and breeding lines for drought resistance. 1983. A.J. Liebenberg
- GG.2134/30/1/4: The evaluation of the International Bean Yield and Adaptation Nursery (IBYAN) of CIAT. 1983. A.J. Liebenberg
- GG.2134/30/1/5: The evaluation of the International Bean Rust Nursery (IBRN) of CIAT. 1983. A.J. Liebenberg
- GG.2134/30/1/6: Effect of temperature on the vegetative and reproductive development of some South African dry bean (*Phaseolus vulgaris*) cultivars. 1983. E.D. Lloyd
- GG.2134/30/1/9: Tolerance of soybean, sunflower and dry bean cultivars to Al toxicity. 1982. A.J. Liebenberg
- GG.2134/30/2/1: The influence of planting date on dry bean cultivars under different soil moisture levels. 1983. A.J. Liebenberg

LUPINS/LUPIENE

• Physiology/Fisiologie

- GG.2135/03/1/1: A study on the effect of daylength and temperature on the growth and development of *Lupinus albus*, *Lupinus mutabilis* and other lupin species. 1985. J.A.M. van der Mey
- GG.2135/03/2/1: A survey on the occurrence of different alkaloids in lupin species and lines for the summer rainfall areas. 1985. J.A.M. van der Mey
- GG.2135/03/2/2: Testing for seed coat hardness in lupin species and lines for the summer rainfall areas. 1985. J.A.M. van der Mey

• Nutrition/Voeding

- GG.2135/05/1/1: The influence of fertiliser placement on germination, growth, development and seed yield of lupins. 1985. H.L. Loubser
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- TK.2141/03/1/3: The effect of moisture stresses and lower night temperatures on CO₂ absorption of short-season cotton cultivars. 1988. D. Meyer
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- *Crop science/Gewaskunde*

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- *Nutrition/Voeding*

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- *Upgrading/Veredeling*

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- *Pathology/Patologie*

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DEPARTMENTAL GENE BANKS/DEPARTEMENTELE GENEBAKKE

Horticulture research/Tuinbounavorsing

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- *Crop science/Gewaskunde*

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GRAPE VINES/WINGERD

- *Upgrading/Veredeling*

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• *Physiology/Fisiologie*

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- GS.2421/19/2/3: Epidemiology of bacterial spot and speck on tomato seedlings. 1989. J.J. Serfontein
- GS.2421/19/3/1: Identification and characterisation of the potyvirus group in tomatoes. 1981. G.J. Thompson
- GS.2421/19/3/2: Identification and characterisation of tomato spotted wilt virus strains. 1981. G.J. Thompson

• *Pests/Plae*

- GS.2421/20/1/1: A study of plant parasitic eelworm on tomatoes. 1981. K.C. Daiber
- GS.2421/20/1/2: Bio-ecological studies of *Liriomyza trifolii* on tomatoes. 1985. M.C. Bolton

• *Crop science/Gewaskunde*

- GS.2421/30/1/1: Evaluation of new market tomato cultivars and breeding lines. 1975. H.A. Dafel
- GS.2421/30/1/2: Evaluation of processing tomato cultivars and breeding lines. 1975. H.A. Dafel
- GS.2421/30/2/2: Effect of growth regulators on the herbicide sensitivity and yield of tomatoes. 1989. A.G. Comrie

GS.2421/30/3/1: Maintenance and multiplication of genetic resources of tomatoes. 1987. D.C.A. Hoffman

GS.2421/30/3/2: Collection and description of genetic resources of tomatoes. 1987. C. Bester

• *Water requirements/Waterbehoefies*

GS.2421/31/1/1: Measurement of tomato leaf water potential. 1985. H.A. Dafel

GS.2421/31/1/2: Water requirements of processing tomatoes. 1986. H.A. Dafel

ONIONS/UIE

• *Upgrading/Veredeling*

GS.2422/07/2/1: The breeding of F₁-hybrid onions. 1983. Elsa van der Klashorst

• *Pathology/Patologie*

GS.2422/19/1/1: Study of *Pyrenochaeta terrestris*, the pink root pathogen of onions. 1983. J.F. Ferreira

GS.2422/19/1/2: Post-harvest decay of onions by *Aspergillus niger*: epidemiology and occurrence. 1987. S.P. Naude

GS.2422/19/1/3: Post-harvest decay of onions by *Aspergillus niger*: control measures. 1986. S.P. Naude

GS.2422/19/1/4: Post-harvest decay of onions by *Aspergillus niger*: histopathology of *A. niger*. 1986. S.P. Naude

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GS.2422/30/1/1: Evaluation of onion cultivars and breeding lines. 1977. A.G. Comrie

GS.2422/30/2/2: Planting density of onions. 1986. A.G. Comrie

GS.2422/30/3/1: Maintenance and multiplication of genetic resources of onions. 1987. P.O. Stork

GS.2422/30/3/2: Collection and description of genetic resources of onions. 1986. Elsa van der Klashorst

COLE CROPS/KOOLGEWASSE

• *Physiology/Fisiologie*

GS.2423/03/1/1: The influence of seed treatments on the germination/physiology of cole crops: cabbage. 1984. B.H. Boelema

• *Pests/Plae*

GS.2423/20/1/1: Study of *Heterodera schachtii* in cole crops. 1987. K.C. Daiber

• *Crop science/Gewaskunde*

GS.2423/30/1/1: Cole crops: phase-II evaluation of cabbage cultivars and breeding lines. 1976. P.J. Henrico

GS.2423/30/1/2: Cole crops: phase-II evaluation of cauliflower cultivars and breeding lines. 1975. C.P.J. Coetzee

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- GS.2423/30/2/1: Maintenance and multiplication of genetic resources of cole crops. 1987. D.C.A. Hoffman
- GS.2423/30/2/2: Collection and description of genetic resources of cole crops: cabbage. 1987. P.J. Henrico
- GS.2423/30/2/3: Collection and description of genetic resources of cole crops: cauliflower. 1987. C.P.J. Coetzee
- GS.2423/30/2/4: Collection and description of genetic resources of cole crops: broccoli. 1987. A.A. van den Berg

ROOT CROP VEGETABLES/WORTELAGTIGE GROENTE

• *Anatomy/Anatomie*

- GS.2424/02/1/1: Root crop vegetables: anatomical studies of root development in sweet potatoes. 1986. C.P. du Plooy

• *Physiology/Fisiologie*

- GS.2424/03/1/1: Root crop vegetables: physiology of storage root initiation and growth in sweet potatoes. 1986. C.P. du Plooy

• *Upgrading/Veredeling*

- GS.2424/07/1/1: Root crop vegetables: breeding and selection of sweet potatoes. 1976. C. Bester
- GS.2424/07/1/2: Root crop vegetables: breeding and selection of industrial sweet potatoes. 1975. C. Bester

• *Pathology/Patologie*

- GS.2424/19/1/1: Root crop vegetables: virus diseases of root crop vegetables: sweet potatoes. 1981. G.J. Thompson

• *Crop science/Gewaskunde*

- GS.2424/30/1/1: Root crop vegetables: phase-II evaluation of sweet potato cultivars and breeding lines. 1975. A.A. van den Berg
- GS.2424/30/4/1: Maintenance and multiplication of genetic resources of root crop vegetables: sweet potatoes. 1987. P.O. Stork
- GS.2424/30/4/2: Collection and description of genetic resources of root crop vegetables: sweet potatoes. 1987. C. Bester
- GS.2424/30/4/3: Maintenance and multiplication of genetic resources of root crop vegetables: carrots. 1987. P.O. Stork
- GS.2424/30/4/5: Maintenance and multiplication of genetic resources of root crop vegetables: beetroot. 1987. D.C.A. Hoffman
- GS.2424/30/4/6: Collection and description of genetic resources of root crop vegetables: beetroot. 1987. Elsa van der Klashorst

• *Water requirements/Waterbehoefte*

- GS.2424/31/1/1: Water requirements of root crop vegetables: carrots. 1982. P.F. Nortje

LEGUME VEGETABLES/PEULGROENTE

• *Upgrading/ Veredeling*

GS.2425/07/2/1: Legume vegetables: breeding and selection of green peas. 1975. S.E. Bosch

GS.2425/07/2/2: Legume vegetables: breeding and selection of dry peas. 1977. S.E. Bosch

• *Pathology/ Patologie*

GS.2425/19/1/1: Legume vegetables: a study of halo blight of green beans. 1975. B.H. Boelema

• *Crop science/ Gewaskunde*

GS.2425/30/2/2: Legume vegetables: phase-II evaluation of dry pea cultivars and breeding lines. 1977. C. Bester

GS.2425/30/4/1: Maintenance and multiplication of genetic resources of legume vegetables: green beans. 1987. P.O. Stork

GS.2425/30/4/2: Collection and description of genetic resources of legume vegetables: green beans. 1987. A.A. van den Berg

GS.2425/30/4/3: Maintenance and multiplication of genetic resources of legume vegetables: peas. 1987. P.O. Stork

GS.2425/30/4/4: Collection and description of genetic resources of legume vegetables: peas. 1987. C.E. Rappard

GS.2425/30/5/1: An evaluation of the efficiency and phytotoxicity of herbicides on green beans. 1981. H.A. Dafel

VINE CROPS/RANKGEWASSE

• *Upgrading/ Veredeling*

GS.2426/07/1/1: Vine crop vegetables: breeding and selection of pumpkins. 1976. S.E. Bosch

GS.2426/07/1/2: Vine crop vegetables: breeding and selection of muskmelon. 1976. J.J.B. van Zijl

• *Crop science/ Gewaskunde*

GS.2426/30/1/1: Vine crop vegetables: evaluation of pumpkin cultivars and breeding lines. 1977. C. Bester

GS.2426/30/1/2: Vine crops: phase-II evaluation of muskmelon cultivars and breeding lines. 1976. Elsa van der Klashorst

GS.2426/30/2/1: Weed control studies in pumpkin and squashes. 1982. H.A. Dafel

GS.2426/30/3/1: Maintenance and multiplication of genetic resources of vine crops. 1987. D.C.A. Hoffman

GS.2426/30/3/2: Collection and description of genetic resources of vine crops: pumpkins. 1987. Elsa van der Klashorst

GS.2426/30/3/3: Collection and description of genetic resources of vine crops: muskmelon. 1987. A.G. Comrie

GS.2426/30/3/4: Collection and description of genetic resources of vine crops: watermelons. 1987. C. Bester

• *Technology/ Tegnologie*

GS.2426/52/1/1: Vine crops: cold storage of melons. 1987. A.G. Comrie

SUNDRY VEGETABLES/DIVERSE GROENTE

• Physiology/Fisiologie

- GS.2427/03/1/1: Sundry vegetables: the rapid propagation of asparagus (*Asparagus officinalis*) by means of tissue culture. 1986. Martha M. Slabbert

• Crop science/Gewaskunde

- GS.2427/30/2/1: Sundry vegetables: cultivation studies with lettuce. 1983. C.P. du Plooy
- GS.2427/30/3/1: Maintenance and multiplication of genetic resources of sundry vegetables: garlic. 1987. D.C.A. Hoffman
- GS.2427/30/3/2: Collection and description of genetic resources of sundry vegetables: garlic. 1987. P.J. Henrico

CHICORY/SIGOREI

• Upgrading/Veredeling

- GS.2428/07/1/1: Breeding of chicory. 1989. C. Bester

• Pathology/Patologie

- GS.2428/19/1/2: Evaluation of chicory cultivars for resistance to black rot. 1987. J.F. Ferreira
- GS.2428/19/1/3: Chemical control of black rot in chicory. 1987. J.F. Ferreira
- GS.2428/19/1/4: Causes of stubby root in chicory. 1989. J.F. Ferreira

• Technology/Tegnologie

- GS.2428/52/1/1: Calibration of Nir equipment for the determination of fibre content in chicory. 1988. M. Biemond
- GS.2428/52/1/2: Investigation of alternative methods for the evaluation of chicory quality. 1989. M. Biemond

Flowers and ornamental plants/Blomme en sierplante

PROTEAS

• Physiology/Fisiologie

- GS.2431/03/2/1: Rapid multiplication of proteas in vitro: *Leucospermum*. 1986. B.A. Rugge
- GS.2431/03/2/2: Rapid multiplication of proteas in vitro: *Serruria florida*. 1986. B.A. Rugge
- GS.2431/03/2/3: Rapid multiplication of proteas in vitro: *Protea*. 1987. D.I. Ferreira

• Upgrading/Veredeling

- GS.2431/07/1/2: Hybridisation studies with proteas: genus *Protea*. 1985. G.J. Brits
- GS.2431/07/1/3: Mass selection for the upgrading of certain protea variants: genus *Protea*. 1985. G.J. Brits
- GS.2431/07/1/5: Upgrading of proteas as pot plants: genus *Protea*. 1987. G.J. Brits

- GS.2431/07/2/1: Hybridisation studies with proteas: genus *Leucospermum*. 1985. G.J. Brits
- GS.2431/07/2/2: Upgrading of proteas as pot plants: genus *Leucospermum*. 1987. G.J. Brits
- GS.2431/07/3/1: Hybridisation studies with proteas: genus *Leucadendron*. 1986. B.A. Rugge
- GS.2431/07/3/2: Upgrading of proteas as pot plants: genus *Leucadendron*. 1987. G.J. Brits
- GS.2431/07/4/1: Upgrading of proteas as pot plants: genus *Serruria*. 1987. G.J. Brits

• *Pests/Plae*

- GS.2431/20/1/2: Bio-ecological studies of insects on proteas. 1986. J.H. Coetzee
- GS.2431/20/1/3: Proteas: insects associated with *Protea magnifica* and *Protea laurifolia*. 1988. M.G. Wright
- GS.2431/20/2/1: Taxonomic studies of insects on proteas. 1986. J.H. Coetzee
- GS.2431/20/2/2: Taxonomic studies of mites on proteas. 1986. J.H. Coetzee
- GS.2431/20/3/1: Chemical control measures of pests on proteas. 1986. J.H. Coetzee

• *Crop science/Gewaskunde*

- GS.2431/30/1/2: Evaluation of protea cultivars and selections. 1978. G.J. Brits
- GS.2431/30/2/3: Reproduction of proteas by means of grafting and budding. 1987. D.G. Malan
- GS.2431/30/2/4: Proteas: maximising seed germination percentage in *Leucospermum*. 1988. G.J. Brits
- GS.2431/30/3/2: Cultivation of proteas in inert media. 1987. D.G. Malan
- GS.2431/30/3/3: An investigation into lime tolerant rootstock for proteas. 1987. D.G. Malan
- GS.2431/30/4/1: Maintenance and multiplication of genetic resources of proteas. 1987. G.C. van den Berg
- GS.2431/30/4/2: Collection and description of genetic resources of proteas: genus *Protea*. 1986. G.C. van den Berg
- GS.2431/30/4/3: Collection and description of genetic resources of proteas: genus *Leucospermum*. 1986. G.C. van den Berg
- GS.2431/30/4/4: Collection and description of genetic resources of proteas: genus *Leucadendron*. 1986. G.C. van den Berg
- GS.2431/30/4/5: Collection and description of genetic resources of proteas: genus *Serruria*. 1986. G.C. van den Berg
- GS.2431/30/4/6: Collection and description of genetic resources of proteas: genus *Mimetes*. 1986. G.C. van den Berg
- GS.2431/30/5/2: Proteas: influence of short day cycles on flower induction of *Leucospermum* cv. Red Sunset. 1987. D.G. Malan
- GS.2431/30/5/3: Proteas: influence of flower induction during different times of the year on the time of inflorescence development of *Leucospermum* cv. Red Sunset. 1987. D.G. Malan
- GS.2431/30/5/4: Proteas: influence of partial induction on the development of distal axillary buds on *Leucospermum* cv. Red Sunset shoots. 1987. D.G. Malan
- GS.2431/30/5/5: Prevention of shoot growth cessation in *Leucospermum*. 1987. D.G. Malan
- GS.2431/30/5/6: Proteas: delaying inflorescence development of *Leucospermum*. 1987. D.G. Malan
- GS.2431/30/5/7: Proteas: manipulation of flowering time - improving inflorescence quality in *Leucospermum*. 1988. D.G. Malan
- GS.2431/30/5/8: Proteas: night interruption and the prevention of induction of flower *Leucospermum* cv. Red Sunset. 1987. D.G. Malan

- GS.2431/30/6/1: Proteas: influence of daylength on inflorescence development of *Serruria florida*. 1988. D.G. Malan
- GS.2431/30/7/1: Proteas: inflorescence initiation and development in the genus *Protea*. 1987. D.G. Malan

POT PLANTS/POTPLANTE

• Physiology/Fisiologie

- GS.2432/03/1/1: Rapid multiplication of bulb flower pot plants in vitro: *Lachenalia*. 1982. J.G. Janse van Rensburg
- GS.2432/03/1/3: Rapid multiplication of bulb flower pot plants in vitro: *Amaryllis*. 1987. M. de Bruyn
- GS.2432/03/1/4: Rapid multiplication of bulb flower pot plants in vitro: *Crinum*. 1987. M.M. Slabbert
- GS.2432/03/3/1: Bulb flower pot plants: multiple flower formation of *Lapeirousia*. 1988. E. Louw
- GS.2432/03/4/1: Bulb flower pot plants: in vitro storage of *Lachenalia* shoot tips. 1989. E. Louw

• Upgrading/Veredeling

- GS.2432/07/1/1: Bulb flower pot plants: breeding and selection of *Lachenalia*. 1974. F.L. Hancke
- GS.2432/07/1/2: Pot plants: breeding and selection of intergeneric hybrids of *Amaryllidaceae*. 1987. A.F. Coertze
- GS.2432/07/2/1: Cytogenetical study of bulb flower pot plants: *Lachenalia*. 1983. F.L. Hancke

• Pathology/Patologie

- GS.2432/19/1/1: Identification of the virus diseases of bulb flower pot plants: *Lachenalia*. 1981. J.T. Burger

• Crop science/Gewaskunde

- GS.2432/30/2/1: Bulb flower pot plants: manipulation of the flowering and growth period of *Lachenalia*. 1984. L. Meyer
- GS.2432/30/2/2: Pot plants: in vivo vegetative and corm increasing techniques. 1986. L. Meyer
- GS.2432/30/3/1: Maintenance and multiplication of genetic resources of bulb flower pot plants. 1987. P.J. Klessner
- GS.2432/30/3/2: Collection and description of genetic resources of bulb flower pot plants: *Lachenalia*. 1987. F.L. Hancke
- GS.2432/30/3/3: Collection and description of genetic resources of bulb flower pot plants: *Amaryllidaceae*. 1987. A.F. Coertze

CUT FLOWERS/SNYBLOMME

• Physiology/Fisiologie

- GS.2433/03/1/2: Rapid multiplication of bulbous cut flowers in vitro: *Ornithogalum maculatum*. 1983. J.G. Janse van Rensburg
- GS.2433/03/1/3: Rapid multiplication of bulbous cut flowers in vitro: *Gladiolus*. 1983. M. de Bruyn
- GS.2433/03/1/4: Rapid multiplication of bulbous cut flowers in vitro: *Ornithogalum*. 1986. M. de Bruyn
- GS.2433/03/2/1: Embryo culture studies on bulbous cut flowers: *Gladiolus*. 1984. J.G. Janse van Rensburg

- GS.2433/03/2/3: Embryo culture studies on bulbous cut flowers: *Nerine*. 1987. J.G. Janse van Rensburg
- GS.2433/03/2/4: Embryo culture studies on bulbous cut flowers: *Cyrtanthus*. 1987. J.G. Janse van Rensburg

• *Nutrition/Voeding*

- GS.2433/05/1/1: Nutritional needs of bulbous cut flowers: *Ornithogalum*. 1984. A.F. Coertze

• *Upgrading/Veredeling*

- GS.2433/07/1/1: Bulbous cut flowers: breeding and selection of *Ornithogalum*. 1978. F.L. Hancke
- GS.2433/07/1/2: Bulbous cut flowers: breeding and selection of *Gladiolus*. 1983. S.D. Verryn
- GS.2433/07/2/1: Cytogenetical studies of bulbous cut flowers: *Gladiolus*. 1986. S.D. Verryn
- GS.2433/07/3/1: Sterility studies of bulbous cut flowers: *Nerine*. 1986. G. Sorour

• *Pathology/Patologie*

- GS.2433/19/1/2: Herbaceous cut flowers: synthesis and cloning of a C-DNA probe for *Chrysanthemum* stunt viroid. 1985. G.C. Bothma
- GS.2433/19/3/1: Identification of the virus diseases of certain bulbous cut flowers: *Ornithogalum*. 1981. J.T. Burger
- GS.2433/19/3/2: Virus elimination by means of chemotherapy and meristem culture in bulbous cut flowers: *Ornithogalum*. 1984. B.M. Vcelar
- GS.2433/19/5/1: Bulbous cut flowers: study of *Uromyces transversalis* on *Gladiolus*. 1984. J.F. Ferreira

• *Pests/Plae*

- GS.2433/20/4/2: Shrub-like cut flowers: chemical control of *Pachnoda sinuata* on roses. 1987. J.M.I. Donaldson

• *Crop science/Gewaskunde*

- GS.2433/30/2/2: Cut flowers: manipulation of the flowering and growth period of *Gladiolus*. 1986. L. Meyer
- GS.2433/30/2/3: Bulbous cut flowers: evaluation of *Bulbinella* as cut flower. 1987. E. Louw
- GS.2433/30/3/1: Maintenance and multiplication of genetic resources of bulbous cut flowers. 1987. P.J. Klesser
- GS.2433/30/3/2: Collection and description of genetic resources of bulbous cut flowers: *Ornithogalum*. 1987. F.L. Hancke
- GS.2433/30/3/3: Collection and description of genetic resources of bulbous cut flowers: *Gladiolus*. 1987. S.D. Verryn

FYNBOS

• *Physiology/Fisiologie*

- GS.2435/03/1/1: Determination of germination requirements of fynbos seed - *Helichrysum vestitum*. 1987. D.G. Malan
- GS.2435/03/1/2: Determination of the germination requirements of fynbos -: *Helipterum eximium*. 1987. D.G. Malan

- *Pests/Plae*

GS.2435/20/1/1: Fynbos: interactions between *Audouinia capitata* and associated insects. 1988. M.G. Wright

- *Crop science/Gewaskunde*

GS.2435/30/1/1: Growth and development patterns of fynbos - *Helipterum eximium*. 1987. D.G. Malan
GS.2435/30/1/2: Growth and development of fynbos: *Rumohra adiantiformis*. 1988. D.G. Malan

Pome and stone fruits/Kern- en steenvrugte

APPLES/APPELS

- *Physiology/Fisiologie*

VV.2441/03/2/3: A test for the occurrence of specific replant diseases of apples. 1982. H.J. van Zyl
VV.2441/03/3/3: The application of ELISA and RIA methodology for the quantification of endogenous plant hormones in apples. 1989. J.G.M. Cutting
VV.2441/03/4/2: Effect of different nitrogen sources on the utilisation of nitrogen fertilisers by apples. 1985. J.M. de Villiers
VV.2441/03/5/3: Ethylene synthesis as a maturity index for apples. 1987. S.J. van Eeden
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VV.2441/03/6/10: The mechanism of action of rest-breaking agents in apples. 1986. M.S. North
VV.2441/03/6/11: Control of delayed foliation of apples. 1986. M.S. North
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VV.2441/03/6/13: Stem en russetting of apples. 1986. H.J. van Zyl

- *Nutrition/Voeding*

VV.2441/05/1/5: Determination of the lime requirement of apple orchard soils and the mobility of surface-applied lime in soils. 1984. H. Gerber
VV.2441/05/2/6: Seasonal distribution of nitrogen and potassium fertilisation for apple trees. 1985. C.M. Olivier
VV.2441/05/2/7: Effect of nitrogen potassium and phosphate fertilisation practices on the fruit quality of apples. 1985. C.M. Olivier

- *Upgrading/Veredeling*

VV.2441/07/1/2: Breeding of apple cultivars resistant to scab. 1977. J.H. Acker
VV.2441/07/1/7: Development of Granny Smith apple plants from callus and single cells for use in mutation breeding. 1985. R.E. Pieterse

- *Pathology/Patologie*

VV.2441/19/1/2: Investigation of curative and protective characteristics of existing and new fungicides for apple scab control. 1981. W.F.S. Schwabe

- VV.2441/19/1/6: Isolation techniques for collar and root rot pathogens of apples. 1985. W.A. Smit
- VV.2441/19/1/9: Nature and extent of core rot of apples in the Western Cape. 1988. S.L. de Kock
- VV.2441/19/2/2: Etiology of blister bark of apples. 1987. E.L. Mansveldt
- VV.2441/19/2/3: Genomic fingerprints of pseudomad strains on apples. 1989. E.L. Mansveldt

• *Pests/Plae*

- VV.2441/20/1/3: Bionomics of codling moth on apples. 1982. T.L. Blomefield
- VV.2441/20/2/1: Monitoring systems for pest mites and a mite predatory beetle on apples. 1981. J.H. Botha
- VV.2441/20/2/2: Monitoring systems for pest mites and a mite predatory beetle on apples. 1981. M.A. Venter
- VV.2441/20/3/1: Survey of the different nematode species occurring in Western Cape apple orchards. 1979. H.J. Hugo
- VV.2441/20/3/2: Chemical control of nematodes attacking apple trees. 1980. H.J. Hugo

• *Crop science/Gewaskunde*

- VV.2441/30/1/1: The planting and maintenance of apple cultivars. 1972. J.V. Hadlow
- VV.2441/30/1/2: Second phase evaluation of apple cultivars in the Western Cape. 1971. P.R. Jolly
- VV.2441/30/4/1: Fruit size in apples. 1971. O. Bergh
- VV.2441/30/6/2: Effect of grass and leguminous cover crops on the performance of apple trees. 1986. R.E. Harris

• *Water requirements/Waterbehoefes*

- VV.2441/31/1/2: Effect of irrigation scheduling and soil moisture regime on the yield and quality of apples. 1985. W.A.G. Kotze
- VV.2441/31/1/3: Effect of irrigation system, irrigation schedule and soil management on root development of apple tree and utilisation of applied water. 1985. J.H.M. Karsten

• *Meteorology/Weerkunde*

- VV.2441/33/1/3: Apples: development of a model for the calculation of the optimum date of application of rest-breaking materials. 1986. M.S. North
- VV.2441/33/1/4: Effect of artificial shading on yield and fruit quality of apples. 1986. O. Bergh

• *Technology/Tegnologie*

- VV.2441/52/1/4: Effect of ethylene on apple quality during controlled-atmosphere storage. 1987. A.B. Truter
- VV.2441/52/1/5: Influence of conditioning of apples prior to controlled-atmosphere storage on quality after storage. 1988. A.B. Truter

• *Chemistry/Chemie*

- VV.2441/53/1/2: Composition and nutritive value of apples. 1984. J.A.G. van Rhyn

PEARS/PERE

• *Physiology/Fisiologie*

- VV.2442/03/1/1: Micro-propagation of pear rootstocks. 1988. L.A. Allerman

- VV.2442/03/2/2: Growth control of pears with growth retardants. 1982. H.J. van Zyl
- VV.2442/03/2/3: Development of a test for specific replant disease of pears. 1987. S.H. Nolte
- VV.2442/03/5/4: Anatomical study of poor keeping quality of Bon Chretien pears. 1984. P. van der Merwe

• *Nutrition/Voeding*

- VV.2442/05/1/1: Pears: determination of the effect of soil pH and of potassium and nitrogen fertilisation on the growth, yield and fruit quality of pears. 1982. J. Wooldridge

• *Upgrading/Veredeling*

- VV.2442/07/1/1: Breeding of precocious late pear cultivars. 1977. J.H. Acker
- VV.2442/07/1/4: Mutation breeding in vitro of Packham's Triumph pear to develop a compact growth habit. 1985. R.E. Pieterse

• *Pathology/Patologie*

- VV.2442/19/1/2: Factors affecting the development of calyx-end rot of pears. 1985. S.L. de Kock

• *Pests/Plae*

- VV.2442/20/1/1: Chemical control of codling moth on pears. 1977. T.L. Blomefield

• *Crop science/Gewaskunde*

- VV.2442/30/1/1: The planting and maintenance of pear cultivars. 1970. P.F. Louw
- VV.2442/30/1/2: Second phase evaluation of pear cultivars in the winter rainfall area. 1971. P.R. Jolly
- VV.2442/30/2/1: Evaluation of pear rootstocks in the winter rainfall area. 1971. P. van Huyssteen
- VV.2442/30/3/1: Increasing production of pears. 1978. P. van Huyssteen
- VV.2442/30/3/2: Comparison of training systems for pears in the Groot-Drakenstein area. 1983. P. van Huyssteen
- VV.2442/30/6/1: Effect of the characteristics of ridges on the performance of pear trees. 1986. J. Wooldridge

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- VV.2442/52/1/1: Controlled-atmosphere storage of pears. 1982. A.B. Truter
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- SS.2481/20/1/5: Control of false codling moth in citrus. 1971. P.J. Newton
 SS.2481/20/1/6: Studies on citrus psylla. 1981. M.A. van den Berg
 SS.2481/20/1/7: Integrated pest control of citrus in the Cape Province. 1985. W.J. du Toit
 SS.2481/20/1/8: Ecology, chemical and biological control of citrus mites. 1985. P.F. Fourie
 SS.2481/20/1/9: Citrus: interaction between the citrus psylla and associated micro-organisms. 1986. M.A. van den Berg
 SS.2481/20/1/11: Integrated control of the white powdery scale, (Hemiptera: Coccidae) on citrus. 1987. T. Brink
 SS.2481/20/1/12: Development of techniques for the chemical control of the citrus psylla on citrus. 1989. V.E. Deacon

• *Crop science/Gewaskunde*

- SS.2481/30/1/1: Rough lemon selections as rootstocks. 1968. H.J. Breedt
 SS.2481/30/1/2: Rootstocks for citrus: navels and Valencias. 1969. H.J. Breedt
 SS.2481/30/1/4: Trifoliata hybrids as rootstocks for citrus: navels. 1980. J.G.J. Maritz
 SS.2481/30/2/5: Citrus cultivars and selections - rose grapefruit. 1978. C.F. Human
 SS.2481/30/2/8: Citrus cultivars and selections - early and late maturing navels. 1977. C.F. Human
 SS.2481/30/2/9: Citrus cultivars and selections - easy peelers. 1972. J. Bredell
 SS.2481/30/2/11: Conservation and evaluation of genetic material. 1984. H.J. Breedt
 SS.2481/30/2/12: Evaluation of citrus scion cultivars and selections: navels, mid-seasons Valencias, lemons, grapefruit and mandarines in the Northern Transvaal. 1988. C.F. Human
 SS.2481/30/2/13: Evaluation of citrus scion cultivars and selections: navels, mid-seasons, Valencias, lemons, grapefruit and mandarines in the Eastern Transvaal, Friedenheim. 1988. A.P. Vincent
 SS.2481/30/2/14: Evaluation of citrus scion cultivars: navels, mid-seasons, Valencias, lemons, grapefruit and mandarines in the Eastern Transvaal, Malelane. 1988. C.F. Human
 SS.2481/30/2/15: Evaluation of citrus scion cultivars: navels, mid-seasons, Valencias, lemons, grapefruit and mandarines in the Eastern Cape. 1988. J. Bredell

- SS.2481/30/2/16: Evaluation of citrus scion cultivars and selections: navels, mid-seasons, Valencias, lemons, and mandarines in the Western Cape. 1988. C. Smit
- SS.2481/30/7/1: High density planting of citrus - navels, Valencias and grapefruit. 1985. H.J. Breed
- SS.2481/30/7/2: Dwarfing of citrus trees. 1985. H.J. Breed
- SS.2481/30/8/1: Fruit size studies of citrus/Clementines. 1985. P.J.J. van Rensburg

● *Water requirements/Waterbehoefes*

- SS.2481/31/1/1: Water requirements of citrus at Nelspruit. 1968. S.F. du Plessis
- SS.2481/31/1/2: Water requirements of citrus at Addo. 1976. S.F. du Plessis
- SS.2481/31/1/3: Water requirements of citrus with reference to grapefruit in the Malelane area. 1987. S.F. du Plessis
- SS.2481/31/1/4: Water requirements of citrus in the Citrusdal area: navels. 1988. S.F. du Plessis
- SS.2481/31/1/5: Water requirements of citrus in the Addo area: Valencias. 1988. S.F. du Plessis

● *Chemistry/Chemie*

- SS.2481/53/1/1: Enzymatical reactions involved with greening disease in citrus under orchard conditions. 1985. L.J. van Lelyveld
- SS.2481/53/1/2: Enzymatical reactions for greening disease in citrus tissue culture. 1985. L.J. van Lelyveld

PINEAPPLES/PYNAPPELS

● *Physiology/Fisiologie*

- SS.2482/03/1/1: Development of tissue culture techniques for the production of embryonic callus and protoplasts in pineapples. 1984. M. Fitchet

● *Nutrition/Voeding*

- SS.2482/05/1/1: Nutritional requirements of pineapples in the Eastern Cape Region. 1972. D.B. Dalldorf
- SS.2482/05/1/2: Macro-element fertilisation of pineapples in Zululand. 1972. G. Smart

● *Pathology/Patologie*

- SS.2482/19/1/1: Control of *Phytophthora* damage on pineapples in the Eastern Cape. 1986. D.B. Dalldorf

● *Pests/Plae*

- SS.2482/20/1/1: Preventative and corrective control of soil insects in pineapples. 1986. G.J. Petty
- SS.2482/20/1/3: The possible roll of different pests regarding the occurrence of wilt in pineapples. 1986. P. Willers

● *Crop science/Gewaskunde*

- SS.2482/30/1/6: Plant density and spacing for smooth Cayenne pineapples. 1986. E.R. Dalldorf
- SS.2482/30/1/7: Evaluation of new herbicides for use in pineapples. 1986. E.R. Dalldorf
- SS.2482/30/1/8: Evaluation of flower inductants on pineapples. 1987. D.B. Dalldorf
- SS.2482/30/2/2: Selection and evaluation of smooth Cayenne pineapples in the Eastern Cape. 1988. E.R. Dalldorf

- *Water requirements/Waterbehoefies*

SS.2482/31/1/1: Influence of irrigation on pineapple production. 1981. A.J. Alberts

AVOCADO/AVOKADO

- *Physiology/Fisiologie*

SS.2483/03/1/5: Radioimmunoassay to determine the hormonal status of alternate bearing avocado trees. 1981. J.G.M. Cutting

SS.2483/03/3/1: Physiological indicators for the prediction of quality of avocados. 1985. J.P. Bower

SS.2483/03/3/2: Physiological indicators for the prediction of final harvest date of avocados. 1985. J.P. Bower

- *Nutrition/Voeding*

SS.2483/05/1/1: Macro- and micro-element requirements of avocados. 1970. T.J. Koen

- *Pathology/Patologie*

SS.2483/19/1/2: Resistance of avocado cultivars to root rot. 1972. J.A. Herbert

SS.2483/19/2/1: Identification and control of avocado virus diseases. 1968. S.P. van Vuuren

SS.2483/19/3/1: Control of fruit diseases of avocado by means of antagonistic Phylloplane micro-organisms. 1987. B.Q. Manicom

- *Pests/Plae*

SS.2483/20/1/2: Integrated control of avocado pests with special reference to the heart-shaped scale. 1988. W.J. du Toit

- *Crop science/Gewaskunde*

SS.2483/30/1/1: Evaluation of avocado cultivar combinations in Natal. 1985. B.J. Durand

BANANAS/PIESANGS

- *Physiology/Fisiologie*

SS.2484/03/2/1: Development of tissue culture techniques for the production of embryogenic callus and protoplasts in bananas. 1985. M. Fitchet

SS.2484/03/3/1: Influence of climatic factors and water stress on physiological responses of banana. 1986. J.C. Robinson

- *Nutrition/Voeding*

SS.2484/05/1/1: Optimum leaf analysis for bananas. 1970. B.L. Smit

- *Upgrading/Veredeling*

SS.2484/07/1/1: The evaluation of promising banana selections. 1968. J.C. Robinson

- *Pests/Plae*

SS.2484/20/1/1: Nematodes attacking bananas with special reference to the burrowing nematodes. 1972. E.C. Rabie

- *Crop science/Gewaskunde*

- SS.2484/30/1/1: Determination of optimal plant population and spatial arrangements for bananas. 1980. J.C. Robinson
- SS.2484/30/1/3: Commercial evaluation of tissue-cultured banana plants. 1987. J.C. Robinson

- *Water requirements/Waterbehoefes*

- SS.2484/31/1/2: A critical comparative evaluation of drip and micro-irrigation for bananas. 1986. J.C. Robinson

- *Technology/Tegnologie*

- SS.2484/52/1/1: Improvement of the shelf-life of bananas. 1975. D.H. Swarts
- SS.2484/52/1/2: Controlled-atmosphere storage of bananas. 1983. D.H. Swarts

DIVERSE SUBTROPICAL FRUITS/ALLERLEI SUBTROPIESE VRUGTE

- *Anatomy/Anatomie*

- SS.2485/02/1/4: Diverse subtropical fruits: phenology in relation to guava. 1987. R.J. du Preez
- SS.2485/02/1/5: Effect of rootstock and climate factors on fruit morphogenesis in granadilla. 1987. A.J. Joubert
- SS.2485/02/1/6: Propagation biology of diverse subtropical fruit: the influence of boron on fruit set of mangoes. 1989. W. Schroeder

- *Physiology/Fisiologie*

- SS.2485/03/2/2: Diverse subtropical fruits: development of a shoot tip grafting technique for granadillas. 1985. M. Nel
- SS.2485/03/2/3: Diverse subtropical fruits: development of tissue culture techniques for the production of embryonic callus and protoplasts in mangoes. 1985. G.W. de Winnaar
- SS.2485/03/2/4: Diverse subtropical fruits: clonal propagation of papayas in vitro. 1985. G.W. de Winnaar
- SS.2485/03/2/6: Diverse subtropical fruits: clonal propagation of guavas in vitro. 1988. M. Fitchet

- *Nutrition/Voeding*

- SS.2485/05/1/2: Diverse subtropical fruits: macro- and micro-element requirements of guavas. 1981. T.J. Koen
- SS.2485/05/1/5: Diverse subtropical fruits: macro- and micro-element requirements of mangoes. 1972. B.L. Smith

- *Upgrading/Veredeling*

- SS.2485/07/1/2: Diverse subtropical fruits: breeding and selection of relation to mangoes. 1971. J.C. Snyman
- SS.2485/07/1/3: Diverse subtropical fruits: breeding and selection of relation to guavas. 1970. C.P. Welgemoed
- SS.2485/07/1/4: Diverse subtropical fruits: breeding and selection of relation to litchis. 1981. A.J. Joubert
- SS.2485/07/1/5: Upgrading of maroela. 1982. A.J. Joubert

- *Pathology/ Patologie*

- SS.2485/19/1/4: Diverse subtropical fruits: control of Malelane dieback in guavas. 1982. N.M.G. Grech
- SS.2485/19/1/7: Diverse subtropical fruits: characterisation and control of granadilla virus disease. 1989. R.J. Brand

- *Pests/ Plae*

- SS.2485/20/1/1: Diverse subtropical fruits: the occurrence and control of known and new pests. 1972. E.A. de Villiers
- SS.2485/20/1/3: A study of the white peach scale on granadilla with emphasis on integrated control. 1989. C. Crause

- *Crop science/ Gewaskunde*

- SS.2485/30/1/3: Diverse subtropical fruits: alternative pruning systems with relation to guavas. 1985. A.J. Alberts
- SS.2485/30/1/4: Pruning of diverse subtropical fruits: litchis. 1987. A.J. Joubert

- *Water requirements/ Waterbehoefies*

- SS.2485/31/1/1: Water requirements of diverse subtropical fruit: guavas in the summer rainfall area. 1987. T. Anderson

OTHER SUBTROPICAL CROPS/ANDER SUBTROPIESE GEWASSE

- *Physiology/ Fisiologie*

- SS.2486/03/1/2: Other subtropical crops: clonal propagation of pepper in vitro. 1988. M. Fitchet

- *Nutrition/ Voeding*

- SS.2486/05/1/1: Other subtropical crops: macro- and micro-element requirements of tea. 1975. B.L. Smith

- *Upgrading/ Veredeling*

- SS.2486/07/1/1: Other subtropical crops: breeding and selection of tea. 1971. J.C. Snyman
- SS.2486/07/1/2: Breeding and selection of other subtropical crops: coffee. 1987. A.C. Nel

- *Pests/ Plae*

- SS.2486/20/2/2: Other subtropical crops: integrated control of coffee pests with the emphasis on *Antestiopsis orbitalis* (Westw.). 1986. H. van der Meulen

- *Crop science/ Gewaskunde*

- SS.2486/30/1/1: Planting distances for other subtropical crops with relation to coffee. 1980. K.F.M.T. de Rooster
- SS.2486/30/3/1: Diverse subtropical crops: vegetative propagation of *Coffea canephora* and *C. arabica*. 1989. B. Snijder
- SS.2486/30/3/2: Other subtropical crops: seed propagation of *Coffea canephora* and *C. arabica*. 1989. B. Snijder

- *Meteorology/Weerkunde*

SS.2486/33/1/1: Climate manipulation for other subtropical crops: ginger. 1987. T. Anderson

- *Technology/Tegnologie*

SS.2486/52/1/1: Other subtropical crops: effect of field practice and factory processes on black tea quality. 1984. L.J. van Lelyveld

SS.2486/52/2/1: Post-harvest handling of other subtropical crops: ginger. 1986. D.H. Swarts

- *Chemistry/Chemie*

SS.2486/53/1/1: Other subtropical crops: browning potential of tea clones and seedlings. 1984. L.J. van Lelyveld

SS.2486/53/1/2: Diverse subtropical crops: the role of polyphenols on the quality of tea. 1989. L.J. van Lelyveld

Nut crops/Neutgewasse

NUTS/NEUTE

- *Nutrition/Voeding*

SS.2491/05/1/1: Macro- and micro-element requirements of macadamia nuts. 1968. R.A. Abercrombie

- *Pests/Plae*

SS.2491/20/1/1: The occurrence and control of pests on nut crops. 1972. E.A. de Villiers

- *Crop science/Gewaskunde*

SS.2491/30/1/2: Testing of pecan nut cultivars. 1971. A.J. Joubert

SS.2491/30/2/1: Testing of planting distances of macadamia nuts. 1971. J.H. Oosthuysen

SS.2491/30/3/1: Tree respons to pruning and manipulation of nut trees: pecan nut trees. 1987. J.H. Oosthuysen

SS.2491/30/3/2: Tree response to pruning and manipulation of nut trees: macadamia trees. 1987. J.H. Oosthuysen

VV.2491/30/1/1: Second phase evaluation of almond cultivars in the Western Province. 1971. E.J. van Zyl

VV.2491/30/1/2: Nuts: evaluation of pecan nut cultivars in the High- and Middleveld of Transvaal. 1983. T.K. Haulik

VV.2491/30/1/3: Nuts: second phase evaluation of almond cultivars in the summer rainfall area. 1987. R.A.W. Gardner

Radioisotopes/Radioisotope

RADIOISOTOPY/RADIOISOTOPIE

- *Chemistry/Chemie*

VV.24101/53/1/2: Radiochemical separation of ²⁸Mg and ²⁸Al in a radioisotope generator. 1983. H. Gerber

Sundry horticultural crops/Diverse tuinbougewasse

HORTICULTURAL CROPS/TUINBOUGEWASSE

• *Physiology/Fisiologie*

GS.24/11/03/2/1: Horticultural crops: study of recalcitrant seeds. 1988. J.T. Meynhardt

• *Nutrition/Voeding*

- VV.24/11/05/1/2: Horticultural crops: nitrogen, potassium and boron fertilisation of olives. 1981. K. Bothma
- VV.24/11/05/1/3: Horticultural crops: seasonal uptake of mineral nutrients by olive trees. 1987. J.F. de Villiers
- VV.24/11/05/3/1: Horticultural crops: seasonal uptake of nutrient elements by kiwi fruit. 1983. J.F. de Villiers
- VV.24/11/05/3/2: Horticultural crops: nitrogen and potassium fertiliser requirement of kiwi fruit. 1987. L. Carstens

• *Crop science/Gewaskunde*

- GS.24/11/30/1/1: Chemical weed control studies with the horticultural crop: guayle. 1981. H.A. Dafel
- GS.24/11/30/2/1: Cultivation studies with the horticultural crop: guayle. 1983. H.A. Dafel
- GS.24/11/30/3/1: Evaluation of different cultivars and breeding lines of the horticultural crop guayle under dryland conditions. 1981. H.A. Dafel
- VV.24/11/30/1/1: Horticultural crops: evaluation of imported olive cultivars in the Paarl, Clanwilliam and Robertson areas. 1981. C. Costa
- VV.24/11/30/1/2: Horticultural crops: evaluation of olive mutations and seedlings in the Paarl and Robertson areas. 1982. C. Costa
- VV.24/11/30/1/3: Horticultural crops: evaluation of olive rootstocks in the Paarl and Robertson areas. 1982. C. Costa
- VV.24/11/30/1/11: Horticultural crops: evaluation of prickly pear cultivars and selection for the Transvaal. 1987. T.K. Haulik
- VV.24/11/30/2/1: Horticultural crops: planting and training systems for olives. 1982. C. Costa
- VV.24/11/30/2/2: Horticultural crops: crop control of olives in the Paarl area. 1982. C. Costa
- VV.24/11/30/5/1: Horticultural crops: evaluation of cultivars and selections of dates. 1984. C.W.J. Bester
- VV.24/11/30/7/1: Second phase evaluation of fig cultivars in the Western Province. 1974. E.J. van Zyl
- VV.24/11/30/8/1: Horticultural crops: second and third phase evaluations of kiwi fruit cultivars in the Western and Southern Cape. 1977. G.C. Linsley-Noakes
- VV.24/11/30/8/2: Horticultural crops: second and third phase evaluation of kiwi fruit cultivars and selections in the summer rainfall area. 1985. L.L. van der Merwe
- VV.24/11/30/10/2: Horticultural crops: artificial rest breaking of kiwi fruit by climatological and chemical manipulation. 1984. G.C. Linsley-Noakes

• *Water requirements/Waterbehoefte*

VV.24/11/31/3/1: Horticultural crops, consumptive water use of kiwi fruit. 1988. O. Beukes

• *Technology/Tegnologie*

VV.24/11/52/1/2: Horticultural crops: processing methods of olives. 1988. P.C. Fourie

- *Chemistry/Chemie*

VV.2411/53/1/1: Horticultural crops: chemical composition of kiwi fruit. 1988. J.A.G. van Rhyn

PLANT PROTECTION RESEARCH/PLANTBESKERMINGSNAVORSING

Entomology/Zoology/Insektekunde/Dierkunde

INSECTS/INSEKTE

- *Taxonomy/Taksonomie*

- PB.2511/01/1/1: Collection of southern African insects. 1910. G.L. Prinsloo
- PB.2511/01/1/5: Taxonomy of parasitic wasps, Chalcidoidea. 1970. G.L. Prinsloo
- PB.2511/01/1/7: Taxonomy of Neuroptera. 1977. M.W. Mansell
- PB.2511/01/1/9: Taxonomy of Hymenoptera Aculeata. 1978. C.D. Eardly
- PB.2511/01/1/10: Taxonomy of Cicadellidae of southern Africa. 1973. G.L. Prinsloo
- PB.2511/01/1/11: Taxonomy and distribution of weevils (Curculionidae) in southern Africa. 1985. R.G. Oberprieler
- PB.2511/01/1/12: Taxonomy and distribution of Aphidoidea and Coccoidea in southern Africa. 1985. I.M. Millar

- *Pests/Plae*

- PB.2511/20/1/1: Migratory locust control by aerial spray application. 1981. H.D. Brown
- PB.2511/20/1/2: The outbreak dynamics of the African migratory locust. 1981. H.D. Brown
- PB.2511/20/1/3: Aspects of reproduction of *Locustana migratoria* in relation to ageing and available food. 1985. H.D. Brown
- PB.2511/20/2/1: Insects: predators of the harvester termite, *Hodotermes mossambicus*. 1984. Anette Nel
- PB.2511/20/2/2: Insects: bat-eared jackals (*Otocyon megalotis*) as consumers of harvester termites (*Hodotermes mossambicus*). 1984. Anette Nel
- PB.2511/20/2/3: Insects: evaluation of insecticides for use in baits against the harvester termite. 1985. Anette Nel
- PB.2511/20/2/4: Aspects of the population dynamics of the harvester termite *Hodotermes mossambicus* in the Bloemfontein district. 1985. Anette Nel
- PB.2511/20/2/5: The effect of termites on the natural veld in the Bloemfontein district. 1986. Anette Nel
- PB.2511/20/2/6: Insects: food preference of harvester termites and possible bait improvement. 1987. F.D. Duncan

- *Biological control/Biologiese beheer*

- PB.2511/22/2/1: The use of natural enemies to control stalk borers in cereal crops. 1978. A.R. Kfir
- PB.2511/22/3/1: Development of a computerised data system for insect pests and their natural enemies. 1983. H. van Hamburg
- PB.2511/22/3/2: Handling and regulation of imported natural enemies of insect pests under quarantine conditions. 1983. H. van Hamburg

- *Integrated control/Geïntegreerde beheer*

- PB.2511/23/1/2: The effect of pesticides applied under field conditions against *H. armiger* on natural enemies and red spider mite. 1978. J.D. Mohr

- PB.2511/23/1/5: The use of natural enemies to control *H. armiger*. 1978. H. van Hamburg
- PB.2511/23/3/1: Evaluation of insecticides against insects which attack the spineless cactus. 1983. M.W. Pretorius

NEMATODES/AALWURMS

• *Taxonomy/Taksonomie*

- PB.2512/01/1/1: Collection of nematodes in southern Africa. 1962. Esther van den Berg
- PB.2512/01/1/3: Taxonomy of root-knot nematodes, *Meloidogyne* spp. 1981. K.P.N. Kleynhans
- PB.2512/01/1/4: Taxonomic study of the South African Longidoridae. 1976. Esther van den Berg

MITES/MYTE

• *Taxonomy/Taksonomie*

- PB.2513/01/1/1: Collection of mites of agricultural importance. 1959. Magdalena K.P. Meyer
- PB.2513/01/1/2: Taxonomy and biology of predacious mites in South Africa. 1962. E.A. Ueckermann
- PB.2513/01/1/3: Taxonomy of free-living Acari in South African soils. 1976. Magdalena K.P. Meyer

• *Integrated control/Geïntegreerde beheer*

- PB.2513/23/1/1: Integrated control of spider mite species of agronomic crops. 1986. N.C.J. Basson

SPIDERS/SPINNEKOPPE

• *Taxonomy/Taksonomie*

- PB.2514/01/1/1: Taxonomy of agriculturally important spiders. 1976. A.S. Dippenaar

HONEY-BEE/HEUNINGBY

• *Nutrition/Voeding*

- PB.2516/05/1/2: Nectar and pollen flora of South Africa. 1969. M.F. Johannsmeier
- PB.2516/05/1/3: The effect of *Drosophila* spp. on the nectar supply of eucalyptus flowers. 1983. A.P. du Toit

• *Upgrading/Veredeling*

- PB.2516/07/1/1: The selection of improved breeding lines of honey-bees. 1972. R.H. Anderson

• *Pathology/Patologie*

- PB.2516/19/1/1: Diseases of the adult honey-bee. 1976. B. Buys

• *Pests/Plae*

- PB.2516/20/1/1: Control of the Argentine ant at bee hives. 1988. B. Buys

• *Behavioural studies/Gedragstudies*

- PB.2516 28.1 1: The behaviour of honey-bees in orchards during pollination. 1972. R.H. Anderson

- *Pollination/ Bestuiwing*

PB.2516/29/1/1: The effect of honey-bees on sunflower pollination. 1985. A.P. du Toit

STORED GRAIN/OPGEBERGDE GRAAN

- *Pests/ Plae*

PB.2518/20/1/4: The biology, distribution and identification of the genera *Trogoderma* and *Phradonoma* (Coleoptera: Dermestidae) in stored grain in South Africa. 1987. M. Jonsson

FOREST AND TIMBER/BOSBOME EN TIMMERHOUT

- *Pests/ Plae*

- PB.2519/20/1/1: The biology, fungal associations and control of bark beetles on pine trees. 1979. G.D. Tribe
- PB.2519/20/1/3: The biology, pest status and control of the black pine aphid. 1977. N.J. van Rensburg
- PB.2519/20/1/4: Forest and timber: the biology of the pine woolly aphid. 1982. A.J. Urban
- PB.2519/20/1/5: Forest and timber: the biology and behaviour of natural enemies of pine aphids. 1984. J.F. Kirsten
- PB.2519/20/1/7: Forest and timber: biology and control of beetle pests of *Eucalyptus* spp. 1984. G.D. Tribe
- PB.2519/20/1/8: The biology of insect pests of furniture timber plantations. 1986. J.F. Morrison
- PB.2519/20/1/9: The ecology and control of termites in forestry plantation. 1987. P.R. Atkinson

Plant pathology/Microbiology/Plantpatologie/Mikrobiologie

FUNGI/SWAMME

- *Taxonomy/ Taksonomie*

- PB.2521/01/1/1: Identification of diverse fungi. 1973. A.P. Baxter
- PB.2521/01/1/4: Taxonomy of fungi: Coelomycetes of South Africa. 1982. C. Roux
- PB.2521/01/1/6: Taxonomy of fungi: *Fusarium* species in South Africa. 1984. R.Y. Anelich
- PB.2521/01/2/1: Taxonomy of Ascomycetes: ontogeny of certain loculoascomycetes. 1988. E.J. van der Linde

- *Mycology/ Mikologie*

- PB.2521/11/1/1: Examination of diverse feeds for toxigenic fungi. 1978. C. Roux
- PB.2521/11/1/2: Role of toxigenic fungi in the occurrence of hepatogenous photosensitivity in livestock. 1971. C. Roux

- *Pathology/ Patologie*

- PB.2521/19/1/2: Seed-borne fungi of dry beans. 1982. A.P. Baxter
- PB.2521/19/5/2: Factors affecting sporulation infection and disease development by the fungus *D. dematioides*. 1985. Sharon L. von Broembsen
- PB.2521/19/5/3: Control of pin cushion blight caused by the fungus *D. dematioides*. 1986. Sharon L. von Broembsen

- PB.2521/19/6/1: Epidemiology of diseases caused by fungi of the genus *Rhizoctonia*. 1987. A.J.L. Phillips
- PB.2521/19/6/2: Biology of fungi of the genus *Rhizoctonia*. 1987. A.J.L. Phillips
- PB.2521/19/6/3: Evaluation of possible methods for control of diseases caused by *Rhizoctonia*. 1987. A.J.L. Phillips

BACTERIA/BAKTERIEë

• Nitrogen fixation/Stikstofbinding

- PB.2522/09/1/1: Testing of commercial bacterial inoculants for legumes. 1967. J.L. Staphorst
- PB.2522/09/1/2: Selection of *Rhizobium* bacteria for inoculants. 1968. C.J. Otto
- PB.2522/09/1/9: Application of nitrogen fixing bacterial inoculants to legumes through irrigation systems. 1983. J.L. Staphorst
- PB.2522/09/1/10: Development of immunological methods for quality control of legume inoculants containing bacteria. 1985. H.H. Lochner
- PB.2522/09/1/11: Bacteria: possible utilisation of liquid *Rhizobium* inoculant. 1985. C.J. Otto
- PB.2522/09/1/12: Bacteria: investigation of problems experienced with inoculation of pasture legumes. 1985. J.L. Staphorst
- PB.2522/09/1/13: Bacteria: investigation of problems experienced with inoculation of grain legumes. 1985. J.L. Staphorst
- PB.2522/09/1/15: Bacteria: role of lectins in the *Rhizobium*-legume symbiosis. 1986. I.J. Law
- PB.2522/09/1/17: Bacteria: determination of possible genetic changes between soil isolates and laboratory cultures of *Bradyrhizobium* sp. (Lotus). 1986. H.H. Lochner
- PB.2522/09/1/18: Bacteria: competition studies with root nodule bacteria and comparison of isolates of a strain of *Bradyrhizobium* sp. (Lotus) from established soil populations and laboratory cultures. 1986. H.H. Lochner

• Pathology/Patologie

- PB.2522/19/1/1: Identification and control of bacterial pathogens of crops from various regions and institutes. 1979. C.C.P.R. Deschodt
- PB.2522/19/1/2: Elimination of seed-borne bacterial pathogens from bean seed. 1974. C.C.P.R. Deschodt
- PB.2522/19/1/3: Bacteria: identification and elimination of bacterial pathogens from soybean cultivars. 1985. C.C.P.R. Deschodt
- PB.2522/19/1/4: Bacteria: identification and elimination of bacterial pathogens from *Brassica* sp. 1985. C.C.P.R. Deschodt
- PB.2522/19/1/5: Bacteria: identification and elimination of bacterial pathogens on Guar. 1985. C.C.P.R. Deschodt
- PB.2522/19/1/6: Bacteria: survey of bacterial pathogens on pasture legumes and determination of host range. 1986. C.C.P.R. Deschodt

• Biological control/Biologische beheer

- PB.2522/22/1/1: Bacteria: isolation, identification and biotyping of *Agrobacterium* spp. from plants and soil. 1985. F.G.H. van Zyl
- PB.2522/22/1/2: Bacteria: the determination of agrocin production and sensitivity of local pathogenic and non-pathogenic *Agrobacterium* species. 1985. F.G.H. van Zyl
- PB.2522/22/1/3: Bacteria: the evaluation of D286 as control strain for crown gall where K84 appears to be unsuccessful. 1985. F.G.H. van Zyl
- PB.2522/22/1/4: Bacteria: the role of competition and specificity of the plant cell binding sites in the biological control of crown gall. 1985. J.L. Staphorst

- PB.2522/22/1/5: Bacteria: the role of agrocins in the biological control of crown gall. 1985. J.L. Staphorst
- PB.2522/22/1/6: Bacteria: the determination of factors in the Boland that is responsible for the possible suppression of crown gall on grapevine. 1985. F.G.H. van Zyl
- PB.2522/22/1/7: Development of agrocin producing strains of *Agrobacterium tumefaciens*. 1984. J.L. Staphorst

VIRUSES/VIRUSSE

• Virology/Virolgie

- PB.2523/12/1/1: Investigation on the virus nature of grapevine leafroll disease. 1985. D.J. Engelbrecht
- PB.2523/12/1/2: Investigations on the mealybug transmission of viruses associated with grapevine leafroll disease. 1985. D.J. Engelbrecht
- PB.2523/12/1/3: Development of immunological virus detection procedures for grapevine diseases. 1985. D.J. Engelbrecht
- PB.2523/12/1/4: Development of nucleic acid coupled virus detection procedures for grapevine diseases. 1985. R. Human
- PB.2523/12/1/5: Detection and identification of seed-transmitted viruses in soybeans. 1985. G. Pietersen
- PB.2523/12/1/6: Detection and identification of seed-transmitted viruses in lupins. 1985. P.M.B. Snyman
- PB.2523/12/1/7: Detection and identification of seed-transmitted viruses in beans. 1986. M.J. Koch

FOREST AND TIMBER/BOSBOOM EN TIMMERHOUT

• Pathology/Patologie

- PB.2525/19/1/6: Integrated control of forest tree diseases. 1983. A.E. Lundquist
- PB.2525/19/2/1: Forest and timber: pathogenicity host range and spread of *Verticillium* spp. causing root diseases of pines. 1985. M.J. Wingfield
- PB.2525/19/5/1: Forest and timber: host range, pathogenicity and distribution of *Mycosphaerella* needle disease of pines. 1986. M.J. Wingfield
- PB.2525/19/10/2: Forest and timber: routine diagnosis of forest tree diseases in the Cape Province and Natal. 1985. M.J. Wingfield

PASTURE CROPS/WEIDINGSGEWASSE

• Pathology/Patologie

- PB.2526/19/1/9: Pasture crops: seed-borne fungal pathogens and disease transmission by seed of *Medicago* spp. 1986. S.C. Lamprecht
- PB.2526/19/1/10: Pasture crops: survival and infection of *Fusarium avenaceum* on annual *Medicago* spp. 1986. S.C. Lamprecht
- PB.2526/19/1/11: Pasture crops: the role of *Fusarium* in a wheat-medic crop rotation system. 1986. S.C. Lamprecht
- PB.2526/19/1/13: Pasture crops: assessment of disease resistance of cultivated lucerne cultivars to above and below ground pathogens in South Africa. 1986. S.C. Lamprecht

Electron microscopy/Elektronmikroskopie

ELECTRON MICROSCOPY/ELEKTRONMIKROSKOPIE

• Technology/Tegnologie

- PB.2541/52/1/1: Preparation and examination of biological specimens by electron microscopy. 1979. H.J. van Tonder

WEEDS/ONKRUIDE

● *Physiology/Fisiologie*

- PB.2551/03/1/1: Physiology of veld invader weeds' seed germination. 1981. P.L. Campbell
 PB.2551/03/2/2: Eco-physiology of jointed cactus (*Opuntia aurantiaca*). 1984. S. Naser

● *Chemical control/Chemiese beheer*

- PB.2551/21/1/1: Chemical control of the weed jointed cactus (*Opuntia aurantiaca*). 1960. H.G. Zimmermann
 PB.2551/21/1/2: Chemical control of the weed nassella tussock (*Stipa trichotoma*). 1980. G.B. Harding
 PB.2551/21/1/3: Chemical control of the weed mesquite (*Prosopis* spp.). 1983. G.B. Harding
 PB.2551/21/1/4: Chemical control of alien veld invaders in Natal. 1983. D.J. Erasmus
 PB.2551/21/1/5: Chemical control of invader weeds of localised Eastern Cape areas. 1983. B.D. Viljoen
 PB.2551/21/1/7: Chemical control of important weeds and unwanted plants in plantations. 1988. R.P. Denny
 PB.2551/21/1/8: Chemical control of the weed silver leaf bitterapple (*Solanum elaeagnifolium*). 1988. B.D. Viljoen

● *Biological control/Biologiese beheer*

- PB.2551/22/1/1: Biological control of the weed jointed cactus (*Opuntia aurantiaca*). 1960. H.G. Zimmermann
 PB.2551/22/1/4: Biological control of the weed prickly pear (*Opuntia ficus-indica*). 1960. H.G. Zimmermann
 PB.2551/22/1/5: Biological control of the weed *Lantana camara*. 1972. C.J. Cilliers
 PB.2551/22/1/6: Biological control of the weeds *Hakea sericea*, *H. gibbosa* and *H. saueolens*. 1972. R.L. Kluge
 PB.2551/22/1/7: Biological control of the weed *Hypericum perforatum*. 1972. R.L. Kluge
 PB.2551/22/1/8: Biological control and management of cactus weeds, particularly jointed cactus in South Africa. 1977. S. Naser
 PB.2551/22/1/11: Biological control of undesirable Australian *Acacia* weeds. 1988. G.B. Dennill
 PB.2551/22/1/13: Biological control of the weed *Chromolaena odorata* using natural insect enemies. 1988. R.L. Kluge
 PB.2551/22/1/15: Biological control of the weed spear thistle (*Cirsium vulgare*). 1988. D.J.R. Noel
 PB.2551/22/1/16: Biological control of the weed *Prosopis*. 1988. H.G. Zimmermann
 PB.2551/22/1/17: Biological control of important aquatic weeds. 1988. C.J. Cilliers
 PB.2551/22/1/18: Biological control of the weed silver leaf bitterapple (*Solanum elaeagnifolium*). 1985. H.G. Zimmermann
 PB.2551/22/2/1: A study of the diseases of some indigenous and exotic weeds which are caused by local pathogens. 1979. M.J. Morris
 PB.2551/22/2/2: Biological control of *Acacia* weeds by means of pathogens. 1982. M.J. Morris
 PB.2551/22/2/5: Biological control of diverse weeds with the aid of pathogens. 1988. M.J. Morris

● *Integrated control/Geïntegreerde beheer*

- PB.2551/23/1/1: Integrated control of the weed *Opuntia aurantiaca* (jointed cactus). 1986. L. Henderson

- *Plant geography/Plantgeografie*

- PB.2551/25/1/1: A survey of alien invasive trees and shrubs in the grassland and savanna biomes. 1986. L. Henderson

- *Ecology/Ekologie*

- PB.2551/27/1/1: Ecology of the weed *Acacia longifolia*. 1983. P.J. Pieterse
 PB.2551/27/1/2: Ecology of the weed nassella tussock (*Stipa trichotoma*). 1983. B.D. Viljoen
 PB.2551/27/1/3: Ecology of the weed *Prosopis* spp. 1988. G.B. Harding
 PB.2551/27/1/10: Reproductive ecology of the weed *Acacia mearnsii*. 1988. P.J. Pieterse

PESTICIDES/PLAAGDODERS

- *Physiology/Fisiologie*

- PB.2552/03/1/2: Effect of pesticide breakdown in soils on phytotoxicity. 1984. E.R.I.C. Sandmann
 PB.2552/03/1/3: A study of climatic factors potentiating pesticide phytotoxicity in legumes. 1984. E. van Rensburg
 PB.2552/03/1/5: Determination of the threshold value for and physiological mechanisms of hormone herbicides in vegetable crops. 1988. L.M. Jordaan

- *Biotesting/Biotoetsing*

- PB.2552/24/1/2: The use of plant cells and plant tissue culture to determine herbicide concentrations. 1985. J.L. Graaf
 PB.2552/24/2/1: The use of the ELISA technique to determine pesticides with auxin mode of action in plants and water. 1989. F. Zuhlsdorff

- *Technology/Tegnologie*

- PB.2552/52/1/3: Study of physical characteristics of pesticide formulations. 1980. H.A. Abott
 PB.2552/52/1/4: The role of adjuvants in the penetration and effectiveness of pesticides. 1985. L.P. van Dyk
 PB.2552/52/1/5: The role of leaf surfaces in the effectiveness of adjuvants and pesticides. 1986. M.J. York

- *Chemistry/Chemie*

- PB.2552/53/1/4: Pesticide residues in raw vegetables, fruit and animal products. 1977. L.P. van Dyk
 PB.2552/53/1/5: Analysis of pesticides and their residues affecting useful plants. 1983. P. Niewoudt
 PB.2552/53/1/6: Research and improvement of pesticide analysis done by the WGPA. 1984. P.R. de Beer
 PB.2552/53/1/7: Development of confirmation techniques for pesticide residue analysis. 1985. Marelie Krause

ANIMAL PRODUCTION PROMOTION DIEREPRODUKSIEBEVORDERING

ANIMAL PRODUCTION AND ANIMAL PRODUCTS RESEARCH DIEREPRODUKSIE- EN DIEREPRODUKTENAVORSING

Animal production/Diereproduksie

BEEF CATTLE/VLEISBEESTE

- *Reproduction/Reproduksie*

- VS.3111/04/1/1: Reproduction in beef cattle: biochemical interrelationships during nutritional stress. 1984. G.W. Kay

- *Upgrading/Veredeling*

- VS.3111/07/1/1: Evaluation of beef bulls in upgrading: Bonsmara. 1980. D.J. Bosman
- VS.3111/07/1/2: Beef cattle: evaluation of the Roodebos and Wesselsvlei Bonsmara breeding lines. 1982. D.J. Bosman
- VS.3111 07 1 3: Upgrading studies on beef cattle - improving fertility by natural selection. 1984. M.M. Scholtz
- VS.3111/07/1/4: Upgrading studies on beef cattle: the effects of selection for growth under different management systems on production efficiency. 1985. J. van der Westhuizen
- VS.3111/07/1/6: Upgrading studies on beef cattle: the influence of the simulation of natural selection of body mass and fertility in a large beef breed. 1985. M.M. Scholtz
- VS.3111 07 1 7: Beef cattle: prediction of breeding values and quantification of genetic trends using mixed model procedures. 1985. C. Hunlun
- VS.3111/07/1/8: Upgrading studies on beef cattle - the estimation of brain mass by using head measurements of cattle and rats. 1985. H.E. Theron

DAIRY CATTLE/MELKBEESTE

- *Physiology/Fisiologie*

- VS.3112/03/1/1: An investigation into in vitro culture techniques for hormone dependent mammary gland tissue in dairy cattle. 1983. J.P. van Zyl
- VS.3112/03/1/2: Milk prolactin surge before and during parturition and production parameters in dairy cattle. 1983. J.P. van Zyl
- VS.3112/03/1/3: Influence of lactation and exogenous peptide hormones on the physiology and metabolism of lipogenic precursors. 1985. S.I. van der Walt

- *Nutrition/Voeding*

- VS.3112/05/1/3: Ureum in complete diets for dairy cattle. 1982. L.J. Erasmus
- VS.3112/05/1/5: Dairy cattle nutrition: establishment of a degradability database. 1985. L.J. Erasmus
- VS.3112/05/1/7: Dairy cattle nutrition: strategic protein nutrition of high producing cows. 1985. B. Ferreira
- VS.3112/05/1/9: Dairy cattle: the in sacco digestibility of amino acid of UDP in the small intestine. 1987. L.J. Erasmus

- *Upgrading/ Veredelings*

VS.3112/07/1/3: Milkability and milk quality characteristics in the upgrading of dairy cattle. 1971. J.H. Hofmeyr

- *Management/ Bestuur*

VS.3112/41/1/1: Biological economic data-analysing service for dairy cattle. 1981. B. Ferreira

MUTTON SHEEP/VLEISSKAPE

- *Upgrading/ Veredelings*

VS.3113/07/1/1: Upgrading of mutton sheep: quantification of genetic and non-genetic components of maternal effects. 1985. J.C. Greeff

WOOLLED SHEEP/WOLSKAPE

- *Upgrading/ Veredelings*

VS.3114/07/1/1: Skin and fibre characteristics in the upgrading of woolled sheep. 1972. O. Steinhagen

VS.3114/07/2/1: Upgrading of reproduction characteristics of woolled sheep by means of cross-breeding. 1972. J.H. Hofmeyr

VS.3114/07/2/2: Upgrading of woolled sheep crosses: evaluation of the Gotlander and its crosses for carpet wool production. 1985. J.C. Greeff

VS.3114/07/2/3: Evaluation of selected cross-bred woolled sheep under normal farm conditions in co-operation with co-operative workers. 1985. J.C. Greeff

PELT SHEEP/PELSSKAPE

- *Reproduction/ Reproduksie*

VS.3115/04/1/1: Reproduction aspects in pelt sheep: freezing of Karakul semen. 1971. J.P.C. Greyling

- *Upgrading/ Veredelings*

VS.3115/07/1/1: Upgrading of pelt sheep - white Karakuls. 1980. J.H. Hofmeyr

MEAT GOATS/VLEISBOKKE

- *Reproduction/ Reproduksie*

VS.3117/04/1/1: Reproduction in the Boer goat: freezing of Boer goat semen. 1974. J.P.C. Greyling

PIGS/VARKE

- *Nutrition/ Voeding*

VS.3119/05/1/5: Pig nutrition: the "ideal protein" requirements of the growing pig. 1984. E.H. Kemm

VS.3119/05/1/6: Pig nutrition: qualitative and quantitative aspects and implications of wheat as feed source. 1984. F.K. Siebrits

VS.3119/05/1/7: Alternative feed sources for pigs - class FH sunflower seed. 1985. J. Viljoen

VS.3119/05/1/11: Pig nutrition: quantification of the variation in apparent digestible content of sorghum. 1987. T.S. Brand

- VS.3119/05/1/12: Digestive physiology and metabolism aspects in animal feeding: lipid metabolism in the vicinity of the break-point in the growth curve of pigs. 1988. J.P. Minnaar
- VS.3119/05/1/13: Pig nutrition: the development of a computer-based pig herd simulation model. 1988. F.K. Siebrits
- VS.3119/05/1/14: Pig nutrition: use of Mobile Nylon Bag Technique (MNBT) on ileorectal anastomosis modified pigs to determine digestible protein and amino acid values at the terminal ileum. 1988. J. Viljoen
- VS.3119/05/1/15: Pig nutrition: the amino acid digestibility of different feedstuffs in the nutrition of the early weaned piglet. 1989. J. Viljoen

• *Upgrading/Veredeling*

- VS.3119/07/1/2: Upgrading of pigs: biochemical genetic typing for identification and parentage control. 1985. A. Swanepoel

CHICKENS/HOENDERS

• *Nutrition/Voeding*

- VS.31110/05/1/1: Nutrition of laying fowls - influence of calcium on phosphorus requirements. 1977. J.J. Prinsloo
- VS.31110/05/1/2: Nutrition of laying fowls - lysine requirements. 1976. F.D.C. Labuschagne
- VS.31110/05/1/3: Nutrition of laying fowls - seasonal energy and protein levels. 1975. F.D.C. Labuschagne
- VS.31110/05/1/5: The use of lupins as feed component in poultry diets. 1987. J.J. Prinsloo
- VS.31110/05/1/6: Evaluation of processing methods of full-fat soybeans in broiler diets. 1988. B.J. Welgemoed
- VS.31110/05/1/7: The use of a high protein sunflower oilcake meal as feed component in poultry diets. 1989. J.J. Prinsloo

• *Upgrading/Veredeling*

- VS.31110/07/1/1: Upgrading of laying fowls - sex-linked feather colour. 1972. J.J. Joubert
- VS.31110/07/1/2: Upgrading of laying fowls - red or gold feather colour. 1971. J.J. Joubert
- VS.31110/07/1/3: Upgrading of laying fowls - combining activity. 1971. J.J. Joubert
- VS.31110/07/1/4: Upgrading of laying fowls - Australorp. 1971. J.J. Joubert
- VS.31110/07/1/5: Upgrading of laying fowls - other breeds. 1972. J.J. Joubert
- VS.31110/07/1/6: Upgrading of laying fowl breeds - New Hampshire control flock. 1976. J.J. Joubert
- VS.31110/07/1/7: Genotype environment interaction in laying fowls - upgrading of laying fowl breeds. 1976. J.J. Joubert
- VS.31110/07/2/1: Upgrading of meat type male line fowls. 1975. J.J. Joubert
- VS.31110/07/2/2: Upgrading of meat type hen line fowls. 1962. J.J. Joubert
- VS.31110/07/2/3: Male and female line genetic control flocks. 1987. J.J. Joubert

OTHER POULTRY/ANDER PLUIMVEE

• *Nutrition/Voeding*

- VS.31115/05/1/1: Nutrient requirement of other poultry - Chinese geese. 1965. J.J. Prinsloo
- VS.31115/05/1/2: Nutrient requirement of other poultry feeding systems - ducks. 1977. M.D. Olver

• *Upgrading/Veredeling*

- VS.31115/07/1/1: Upgrading of other poultry - Hagedoorn system with ducks. 1965. M.D. Olver

Animal products/Diereprodukte

MEAT/VLEIS

• Norm studies/Normstudies

- VS.3121/50/1/2: Meat production: carcass evaluation - cattle. 1975. J.F. de Bruyn
- VS.3121/50/1/3: Meat production: chilling of beef carcasses. 1976. P.H. Heinze
- VS.3121/50/1/8: Meat production: carcass grading system - small stock. 1981. G.G. Bruwer
- VS.3121/50/1/9: Meat production: compensatory growth - cattle. 1982. J.F. de Bruyn
- VS.3121/50/1/11: Meat production: porcine stress syndromes. 1984. P.H. Heinze
- VS.3121/50/1/15: The influence of chilling and other environmental factors on the shelf-life of meat. 1987. G.L. Nortje
- VS.3121/50/1/16: A comparison between the agar impression technique, the modified agar impression technique and the excision technique to determine the bacterial contamination of meat. 1987. S.J. Botha
- VS.3121/50/1/18: Nutritional and quality characteristics of beef. 1988. H.C. Schönfeldt
- VS.3121/50/1/19: Survey of the meat product industry of the Republic of South Africa. 1988. I.B. Zondach
- VS.3121/50/1/20: The influence of specif growth promotors on the characteristics of wool, skin and leather and the relationships between skin and leather characteristics of South African Mutton Merino sheep. 1988. A. Liebenberg
- VS.3121/50/2/1: Pork production and meat norm studies: a survey of the carcass characteristics of pig carcasses in the R.S.A. 1987. G.G. Bruwer
- VS.3121/50/2/2: Pork and pork production norm studies: the effects of castration and feeding unsaturated oil (sunflower seed) on the fatty acid composition of pig fat (intra- and extra-muscular). 1987. S.M. de Jong
- VS.3121/50/2/3: Pork production and meat norm studies: carcass evaluation of cross-bred pigs. 1987. G.G. Bruwer
- VS.3121/50/2/4: Meat quality characteristics of cross-bred pigs. 1987 P.H. Heinze
- VS.3121/50/2/5: The development of a classification and grading system for pig meat in South Africa. 1987. G.G. Bruwer
- VS.3121/50/2/6: Meat quality characteristics as influenced by genotype, slaughter mass and sex type. 1987. P.H. Heinze
- VS.3121/50/2/7: Pork fat quality characteristics as influenced by genotype, slaughter mass and sex type. 1987. S.M. de Jong
- VS.3121/50/2/8: The suitability of carcass meats for processing as influenced by genotype, sex type and slaughter mass. 1987. J.C. Venter
- VS.3121/50/2/9: Pork production norm studies: evaluation of sensory characteristics of roasts and processed products as influenced by genotype, sex type and slaughter mass. 1987. I.B. Zondach
- VS.3121/50/3/1: Microbiological and technological properties of fresh pork during slaughtering, deboning, vacuum and gas packaging and distribution. 1987. E.M. Scholtz
- VS.3121/50/4/1: The influence of zinc tannate on sexual development, production and product characteristics of the meat bulls. 1987. P.E. Strydom

MILK/MELK

• Microbiology/Mikrobiologie

- VS.3123/08/1/5: Milk: preservation of milk samples for bacterial count tests. 1983. H. Gavron

- VS.3123/08/2/4: The presence and influence of facultative anaerobic fecal bacteria in milk and milk products. 1987. D. Wessels
- VS.3123/08/2/5: Milk: the occurrence and importance of biofilms in milk pipelines in the dairy industry. 1988. C. Koutzayiotis
- VS.3123/08/3/2: The shelf-life of aseptical-packaged pasteurised milk. 1983. J.F. Mostert
- VS.3123/08/3/4: Presence, isolation and identification of psychrotrophic bacteria in raw milk samples. 1987. G.J. Swart
- VS.3123/08/4/2: Milk: assay of antibiotics. 1983. H. Gavron

• *Norm studies/Normstudies*

- VS.3123/50/1/1: Somatic cell counts in herd milk. 1988. G.J. Swart

• *Technology/Tegnologie*

- VS.3123/52/2/1: Technological control of the metabolic activity of psychrotrophic bacteria. 1987. G.J. Swart

• *Chemistry/Chemie*

- VS.3123/53/1/4: The non-protein nitrogen content of milk in the RSA. 1988. N.H. Robertson
- VS.3123/53/1/5: The relationship between milk protein polymorphism and the production of milk and milk proteins. 1988. D.J. de Lange
- VS.3123/53/2/1: Discolourisation of UHT-milk. 1981. B.G. Venter
- VS.3123/53/4/1: Natural and added iodine in milk. 1981. D. Wessels
- VS.3123/53/4/2: Regional and seasonal tendencies and sources of contamination of pesticides in milk products. 1985. L.E. Smit

DAIRY PRODUCTS/SUIWELPRODUKTE

• *Microbiology/Mikrobiologie*

- VS.3124/08/1/1: Dairy products: a genetic study of the group *N. streptococci*. 1981. H. Gavron
- VS.3124/08/1/3: Dairy products: bacterial content of air in dairy factories. 1983. K. Radmore
- VS.3124/08/1/5: The long chain fatty acid composition as an aid in the identification of the lactic acid streptococci used in commercial starter cultures in South Africa. 1988. H.B. Muller
- VS.3124/08/1/8: The bacteriological composition of commercial cheese starters used in South Africa. 1987. F.S. Botha
- VS.3124/08/2/2: Dairy products: the influence of non-starter organisms on Cheddar cheese. 1983. A.J. Kruger
- VS.3124/08/2/4: Dairy products: the incidence and practical importance of psychrotrophic Enterobacteriaceae in milk and dairy products. 1987. A.L. Malan
- VS.3124/08/3/5: Dairy products: the evaluation of pathogenic bacteria in milk and cheese. 1983. H. Gavron
- VS.3124/08/3/6: Dairy products: screening of South African raw milk for the presence of *Listeria monocytogenes*. 1988. T Wnorowski

• *Norm studies/Normstudies*

- VS.3124/50/1/1: Dairy products: production and quality of butter in South Africa. 1981. J.J. du Toit

• *Technology/Tegnologie*

- VS.3124/52/1/1: Dairy products: technique studies in the concentration of whey and skim milk by ultrafiltration. 1983. T.E.H. Downes

- VS.3124/52/1/2: The use of products recovered by ultrafiltration in dairy products. 1972. T.E.H. Downes
- VS.3124/52/1/5: Dairy products: the development of a low-energy dairy spread with favourable spreadability. 1982. T.E.H. Downes
- VS.3124/52/1/6: Dairy products: demineralisation, processing and utilisation of cheese whey. 1982. A.P. Potgieter
- VS.3124/52/1/10: Hydrolysis of lactose in cheese whey for use in dairy products or other foods. 1984. T.E.H. Downes
- VS.3124/52/1/11: Dairy products: the manufacture of cold water instant full-cream milk powder on a two-stage spray dryer. 1985. T.E.H. Downes

• *Chemistry/Chemie*

- VS.3124/53/3/4: Dairy products: the identification of milk proteins in other foods. 1983. B.G. Venter
- VS.3124/53/3/6: Levels of linoleic acid (trans) in dairy products and oils before and after processing. 1984. L.D. Nourse
- VS.3124/53/3/7: Dairy products versus processed oils as fat-energy source: the disturbance of the metabolism of all cis-linoleic acid by the transforms as measured by growth of broiler chicks. 1984. L.D. Nourse
- VS.3124/53/3/8: Dairy products versus processed oils as fat-energy source: the disturbance of the metabolism of all cis-linoleic acid by the transforms as measured by uncontrolled cell proliferation in tissue cultures. 1984. L.D. Nourse
- VS.3124/53/3/9: The incidence of heavy metals in dairy products. 1985. D.J.W. Bester

Supporting animal research/Ondersteunende veekundige navorsing

ANIMALS/DIERE

• *Reproduction/Reproduksie*

- VS.3133/04/1/2: Animal reproduction: an in vitro rat embryo culture bio-assay to detect exogenous teratogens (lead and copper). 1985. J.M. Burgman
- VS.3133/04/1/3: Animal production: comparative study of the pellet and straw freezing methods of sheep semen by means of the zona-free hamster ovum sperm penetration assay. 1989. H. Hattingh

• *Nutrition/Voeding*

- VS.3133/05/1/9: Feed intake in the nutrition of farm animals - growth studies with beef steers under production conditions. 1984. J.P. Campher
- VS.3133/05/1/10: Feed intake in the feeding of farm animals: quantification of digestive energy losses on different ruminant diets. 1984. N. Slabbert
- VS.3133/05/1/12: Feed intake in the nutrition of farm animals: predicting the voluntary feed intake of South African roughages for growing sheep and cattle. 1988. J.P. Pienaar
- VS.3133/05/2/8: Protein nutrition: factors influencing the efficiency of microbial protein synthesis in the rumen. 1988. A. Kistner
- VS.3133/05/2/9: Protein nutrition: *Geotrichum candidum* as single cell protein for monogastric animals. 1988. F.J. Nell
- VS.3133/05/3/4: Digestive physiology and metabolism aspects in the feeding of farm animals - glucose production. 1975. J.G. van der Walt
- VS.3133/05/3/12: Digestive physiology and metabolism aspects in the feeding of farm animals - bacterial growth, Na⁺ and K⁺. 1980. R.I. Mackie

- VS.3133/05/3/14: Digestive physiology and metabolism aspects in animal feeding - growth constants, cellulolytic bacteria. 1973. R.I. Mackie
- VS.3133/05/3/17: Digestive physiology and metabolism aspects in the feeding of farm animals: ammonia transport and its influence on nitrogen metabolism in rumen bacteria. 1984. Johanna J. Therion
- VS.3133/05/3/18: Digestive physiology and metabolism aspects in the feeding of farm animals: regulation and control of proteases in pure cultures of rumen bacteria. 1984. E. Strydom
- VS.3133/05/3/19: Animals: influence of lactation and nutrition on the metabolism of lipogenic precursors. 1985. J.G. van der Walt
- VS.3133/05/3/20: Digestive physiology and metabolism aspects in animal feeding: partitioning of ruminal acetate and propionate between lipogenesis and gluconeogenesis, respectively in sheep. 1986. M.J. Linington
- VS.3133/05/3/21: Digestive physiology and metabolism aspects in animal feeding - peptide transport and utilisation by rumen bacteria. 1986. K. Westlake
- VS.3133/05/3/23: Digestive physiology and metabolism aspects in animal feeding - development of an *in vitro* method for evaluating protein digestibility. 1987. P.H. Henning
- VS.3133/05/3/24: Digestive physiology and metabolism aspects in animal feeding: ruminal microbial yield during *in vitro* incubation of grain mixtures. 1987. P.H. Henning
- VS.3133/05/3/25: Digestive physiology and metabolism aspects in animal feeding: evaluation of acetate clearance rate as an index of growth rate and lipogenesis in lambs fed roughage-based diets. 1987. P.B. Cronje
- VS.3133/05/3/27: Digestive physiology and metabolism aspects in animal feeding - the relationship between rumen microbial growth efficiency and energy supply pattern *in vitro*. 1988. P.H. Henning
- VS.3133/05/3/28: Digestive physiology and metabolism aspects in animal feeding - evaluation of protected fats for inclusion in ruminant diets. 1988. P.B. Cronje
- VS.3133/05/3/30: Digestive physiology and metabolism aspects in the feeding of farm animals: changes in blood composition associated with the stress of fasting in cattle. 1989. J.P.C. Greyling
- VS.3133/05/4/4: Crop residues of by-products for animal nutrition - pigs and poultry. 1982. J. Viljoen
- VS.3133/05/4/7: Evaluation and upgrading of crop residues and fibrous industrial waste and by-products as feed source for ruminants. 1988. R. Meeske
- VS.3133/05/6/5: Dietary components in feeds for animal feeding: whole maize grain. 1984. J.P. Campher
- VS.3133/05/6/6: Dietary components in feeds for animal feeding: combinations of energy sources. 1985. P.H. Henning
- VS.3133/05/6/7: Dietary components in feeds for animal feeding: water-reconstituted grain sorghum in fattening diets for beef steers. 1985. N. Slabbert
- VS.3133/05/6/8: Dietary components in feeds for animal feeding: the influence of grain softness on the utilisation of whole maize by beef steers. 1985. N. Slabbert
- VS.3133/05/6/9: Dietary components in feeds for animal feeding: ammoniated grain sorghum in fattening diets for beef steers. 1987. N. Slabbert
- VS.3133/05/6/10: Dietary components in feeds for animal feeding: the utilisation of whole grain from different maize cultivars in fattening diets of beef steers. 1988. N. Slabbert

• *Genetics/Genetika*

- VS.3133/06/1/4: Genetic aspects of blood typing in farm animals. 1969. S.J. du Plessis.
- VS.3133/06/1/5: Genetic production models for farm animals - milk production. 1977. C.Z. Roux
- VS.3133/06/1/6: Laboratory animals in genetic studies: efficiency of feed utilisation. 1978. M.M. Scholtz
- VS.3133/06/1/9: Genetic aspects of karyotyping in farm animals. 1978. N.D. Nel
- VS.3133/06/1/10: Laboratory animals in genetic studies: milk production estimation techniques - rats. 1982. M.M. Scholtz

- VS.3133/06/1/11: The genetic maintenance of small animal populations and the effect of in-breeding on production characteristics. 1982. J.C. Greeff
- VS.3133/06/1/12: Genetic studies on farm animals: preparation of monospecific anti-sera against lymphocyte antigens for investigation into the immune system of cattle. 1985. J. Bester

• *Upgrading/ Veredeling*

- VS.3133/07/1/1: Upgrading studies on indigenous animals - maintenance, evaluation and improvement of indigenous Sanga cattle. 1982. M.M. Scholtz
- VS.3133/07/1/2: Upgrading studies on indigenous animals - cytogenetic studies on Nguni cattle. 1982. N.D. Nel
- VS.3133/07/1/3: Upgrading of animals: the evaluation of highly fertile sheep - breeds and strains in crosses. 1982. J.C. Greeff
- VS.3133/07/1/5: Animals: genetic aspects of protein and enzyme polymorphism in sheep and goats. 1985. M.C. Reid
- VS.3133/07/1/6: Upgrading of animals: production models and statistical methods for the breeding of farm animals. 1986. C.Z. Roux
- VS.3133/07/2/1: Biotechnical research for the upgrading of farm animals: the production of monozygotic twins using embryo splitting. 1986. N.D. Nel

Biotechnology/Animal science/Biotegnologie/Veekunde

BIOTECHNOLOGY/BIOTEGNOLOGIE

• *Upgrading/ Veredeling*

- VS.3141/07/1/1: Biotechnological research for the upgrading of farm animals: the production of monozygotic twins using embryo splitting. 1986. N.D. Nel
- VS.3141/07/1/2: Biotechnological research for the upgrading of farm animals: genome mapping by restriction fragment length polymorphisms in livestock. 1987. N.D. Nel

VETERINARY RESEARCH/VEEARTSENYKUNDIGE NAVORSING

Pathological investigations/Patologiese ondersoeke

PATHOLOGICAL INVESTIGATIONS/PATOLOGIESE ONDERSOEKE

• *Pathology/ Patologie*

- OP.3211/19/1/1: Diagnostic pathological investigations into mortalities of animals through macro- and microscopical techniques. 1981. J.A.W. Coetzer
- OP.3211/19/1/2: Diagnostic investigations into mortalities through electron microscopical techniques. 1981. L. Prozesky
- OP.3211/19/2/8: Pathological investigations: toxicology, clinical pathology and pathology of *Cestrum laevigatum* poisoning in sheep and cattle. 1985. J.J. van der Lugt
- OP.3211/19/2/9: The documentation of the toxicological chemical, chemical-pathological and pathological aspects of *Crotalaria sparioides* poisoning in rabbits and cattle. 1986. J.J. van der Lugt
- OP.3211/19/2/10: Pathological investigations: electron microscopic studies of platelets from lambs infected with Rift Valley fever virus and Wesselsbron disease virus. 1986. J.A.W. Coetzer
- OP.3211/19/2/11: Toxicological, pathophysiological and pathological aspects of *Galenia africana* poisoning in sheep. 1986. J.J. van der Lugt

ANIMAL FOODS/DIERLIKE VOEDSELS

• *Pathology/Patologie*

- OP.3221/19/1/1: Animal foods: diagnosis of mastitis as a herd problem. 1981. W.H. Giesecke
- OP.3221/19/1/2: Animal foods: microscopical investigation of the teat tip and canal at different stages of udder development. 1982. I.M. Clayden
- OP.3221/19/1/3: Animal foods: lacteal levels of glucose and frequencies of subclinical mastitis and other udder conditions. 1981. W.H. Giesecke
- OP.3221/19/1/5: Animal foods: the effect of teat dipping on subclinical udder conditions in dairy cows milked by a machine. 1982. W.H. Giesecke
- OP.3221 19 1 7: Animal foods: normal bacterial flora on bovine udders as affected by age, breed and season. 1979. Anette M. Durand
- OP.3221/19/1/9: Animal foods: interlaboratory standardisation of somatic cell counts in cows' milk in the RSA. 1983. W.H. Giesecke
- OP.3221 19 1 10: Animal foods: the development of the methodology for an investigation of primary prostaglandins and thromboxanes in the normal and pathological udder secretion. 1985. Z.E. Kowalski
- OP.3221/19/1/11: Animal foods: a methodological investigation of the lipoxigenase products of arachidonic acid in normal and pathological udder secretions and tissue homogenates. 1985. Z.E. Kowalski
- OP.3221 19 1 12: Animal foods: determination of ketones in bovine milk by headspace gaschromatography. 1989. H. Winterbach
- OP.3221/19/1/13: The role and significance of catecholamines in bovine udder health. 1989. J.H. du Preez
- OP.3221 19 1 14: The role and significance of reducing sugars relative to catecholamines in blood and milk of dairy cattle. 1989. J.H. du Preez
- OP.3221/19/3/1: Animal foods: potentially pathogenic micro-elements in animal feeds. 1981. Anette M. Durand
- OP.3221/19/3/4: The use of bacterial adenosinetriphosphate (ATP) analysis for the determination of the bacteriological quality of animal feeds. 1985. S.M. Payze

• *Technology/Tegnologie*

- OP.3221/52/2/1: Animal foods: differentiation of the species origin of different meat types. 1983. W.H. Giesecke

Toxicological investigations/Toksikologiese ondersoeke

TOXIC SUBSTANCES/TOKSIESE STOWWE

• *Toxicology/Toksikologie*

- OP.3231/18/1/1: Diagnostics of poisoning of animals by toxic substances. 1981. T.S. Kellerman
- OP.3231/18/2/1: The role of fungi, plants and toxic substances in the aetiology and pathogenesis of photosensitivity. 1971. T.S. Kellerman
- OP.3231/18/2/4: Evaluation of the efficacy of medical and industrial activated charcoals in the prophylaxis and treatment of plant poisonings and mycotoxicoses. 1984. T.S. Kellerman
- OP.3231/18/2/5: Salinomycin poisoning in horses. 1985. P.W. Nel

- OP.3231/18/2/6: Toxic substances: pathogenesis and early diagnosis of gousiekte. 1987. N. Fourie
- OP.3231/18/2/7: Neonatal effects of diploiosis on livestock. 1988. T.S. Kellerman

Internal parasite investigations/Interne-parasietondersoek

HELMINTHS/HELMINTE

• Taxonomy/Taksonomie

- OP.3241/01/1/1: Identification of helminths and investigation of definite host ranges. 1983. E.L. Visser
- OP.3241/01/1/2: The taxonomy and incidence of helminths of the Cape hyrax (*Procavia capensis*). 1983. E.L. Visser

• Pests/Plae

- OP.3241/20/1/1: Helminths: diagnosis of unknown internal parasite phenomena. 1981. J.A. van Wyk
- OP.3241/20/2/1: Helminths: immunology and serology of cysticercosis of cattle and pigs. 1970. E.L. Visser
- OP.3241/20/2/5: Helminths: epidemiology of tapeworms of ruminants. 1982. E.L. Visser
- OP.3241/20/2/6: Helminths: incidence and treatment of *Stilesia globipunctata* infestation in South Africa. 1983. E.L. Visser
- OP.3241/20/3/1: Helminths: reinfestation of cattle with bilharzia. 1969. J.A. van Wyk
- OP.3241/20/3/2: Helminths: influence of temperature on the development of the larval stages of *Fasciola* spp. 1979. R.M.R. Alves
- OP.3241/20/3/3: Helminths: development of *Fasciola* spp. of cattle and sheep in various definitive hosts. 1978. R.M.R. Alves
- OP.3241/20/3/4: Helminths: pathological physiology of *Schistosoma matthei* infestation of sheep and cattle. 1969. J.A. van Wyk
- OP.3241/20/3/5: Helminths: epidemiology of paramphistomiasis. 1981. J.A. van Wyk

• Chemical control/Chemiese beheer

- OP.3241/21/1/1: Chemical control of helminths with special reference to resistance. 1982. J.A. van Wyk

• Technology/Tegnologie

- OP.3241/52/1/1: Helminths: long-term storage of pure strains of helminths. 1973. J.A. van Wyk
- OP.3241/52/1/2: Recovery of helminths and/or their ova from animals. 1976. J.A. van Wyk
- OP.3241/52/1/3: Helminths: *ante-mortem* determination of worm loads in animals. 1985. J.A. van Wyk
- OP.3241/52/1/4: Helminths: an investigation of various egg counting methods and the development of quicker *post-mortem* techniques for the determination of internal parasite loads. 1987. F.J. de Villiers

Reproduction investigations/Reproduksie-ondersoek

INFERTILITY/ONVRUGBAARHEID

• Pathology/Patologie

- OP.3251/19/1/1: Diagnostics of infertility and abortion in animals. 1973. B. Gummow

- OP.3251/19/1/2: Serodiagnostics of infertility, abortion and other diseases. 1981. C.C. Williamson
- OP.3251/19/2/2: Infertility: immunity to trichomoniasis in cattle. 1981. S. Herr
- OP.3251/19/2/3: Infertility: ulcerative dermatosis in sheep. 1981. C.J.V. Trichard
- OP.3251/19/2/5: Infertility: bacterial infections of the genitalia of sheep. 1981. B.C. Jansen

Entomological investigations/Entomologiese ondersoeke

EXTERNAL PARASITES/EKSTERNE PARASIEETE

• Entomology/Entomologie

- OP.3261/14/1/1: External parasites: identification and systematics of insects of veterinary importance. 1981. E.M. Nevill

• Acarology/Akarologie

- OP.3261/15/1/1: External parasites: identification and systematics of ticks and mites of veterinary importance. 1981. J.B. Walker
- OP.3261/15/1/2: External parasites: systematics of the genus *Rhipicephalus*. 1973. J.B. Walker
- OP.3261/15/1/3: External parasites: identification and systematics of mites of veterinary importance. 1986. L.C. Jordaan

• Pathology/Patologie

- OP.3261/19/1/1: External parasites: *Cowdria ruminantium* in *Amblyomma hebraeum*. 1977. J.D. Bezuidenhout
- OP.3261/19/1/2: External parasites: multiplication of arboviruses in *Culicoides* spp. 1973. E.M. Nevill
- OP.3261/19/1/3: External parasites: aetiology of sweating sickness. 1971. P.T. Oberem
- OP.3261/19/1/4: External parasites: the congenital resistance of new-born calves against heartwater. 1987. J.L. du Plessis
- OP.3261/19/1/8: External parasites: a biochemical study of the tissues of *Rhipicephalus evertsi*, *Hyalomma* spp., *Exodes rubicundus*, *Boophilus* spp. and *Ornithodoros savignyei* with special reference to their toxins. 1984. J.D. Bezuidenhout
- OP.3261/19/1/9: External parasites: determination of the tick load that will ensure enzootic stability with regard to heartwater. 1984. J.L. du Plessis
- OP.3261/19/1/10: External parasites: the epidemiology of Karoo paralysis. 1985. J.D. Bezuidenhout
- OP.3261/19/1/11: External parasites: the in vitro cultivation of *Cowdria ruminantium*. 1985. J.D. Bezuidenhout
- OP.3261/19/1/12: External parasites: the role of complement, conglutinin and immune-conglutinin in the pathogenesis of heartwater. 1985. J.L. du Plessis
- OP.3261/19/1/13: External parasites: the use of the Welgevonden strain of *Cowdria ruminantium* for heartwater research. 1986. J.L. du Plessis
- OP.3261/19/1/14: External parasites: the congenital resistance of new-born calves against heartwater. 1987. J.L. du Plessis

• Pests/Plae

- OP.3261/20/1/3: External parasites: biology and control of *Simulium* spp. in South Africa. 1968. L.C. Jordaan
- OP.3261/20/1/5: External parasites: tick resistance in indigenous and European cattle breeds. 1982. A.M. Spickett

- OP.3261/20/1/6: External parasites: the effects of host immunity of Brahman and Hereford cattle breeds on the dynamics of tick populations in a mixed sourveld environment. 1984. A.M. Spickett
- OP.3261/20/1/7: External parasites: hosts of *Amblyomma hebraeum* and their importance in the epidemiology of heartwater. 1985. J.D. Bezuidenhout

Virus investigations/Virusondersoeke

VIRUSES/VIRUSSE

• Pathology/Patologie

- OP.3271/19/1/1: Diagnostics of virus diseases of animals. 1981. B.J.H. Barnard
- OP.3271/19/2/3: Growth attenuation of African horse sickness viruses in tissue culture. 1968. B.J. Erasmus
- OP.3271/19/2/5: Modification of bluetongue virus in tissue culture. 1970. B.J. Erasmus
- OP.3271/19/2/6: Characterisation of newer orbiviruses. 1973. B.J. Erasmus
- OP.3271/19/2/7: Flavivirus infection of sheep and cattle. 1981. B.J.H. Barnard
- OP.3271/19/2/8: Survey of bluetongue and other viruses in *Culicoides* spp. 1979. B.J. Erasmus
- OP.3271/19/2/9: Viruses: the epidemiology of bovine malignant catarrh. 1983. B.J.H. Barnard
- OP.3271/19/2/10: Viruses: pathogenicity and tick transmission of Crimean Congo haemorrhagic fever in cattle and sheep. 1984. B.J. Erasmus

Highly contagious diseases/Hoogsaansteeklike siektes

HIGHLY CONTAGIOUS VIRUSES/HOOGSAANSTEEKLIKE VIRUSSE

• Pathology/Patologie

- OP.3281/19/1/1: Diagnostics of highly contagious virus diseases of animals. 1980. G.R. Thomson
- OP.3281/19/1/2: Highly contagious viruses: the development of ELISA techniques for the detection of foot-and-mouth disease (FMD) and swine vesicular disease (VSD) viruses and antibodies directed against them. 1985. J.J. Esterhuyzen
- OP.3281/19/2/1: Highly contagious viruses: epidemiology of African swine fever in free-living hosts. 1978. G.R. Thomson
- OP.3281/19/2/3: Highly contagious viruses: the role of wild cloven-hoofed animals in the epidemiology of foot-and-mouth disease. 1981. G.R. Thomson
- OP.3281/19/2/4: Highly contagious viruses: assessment of foot-and-mouth disease vaccines. 1983. C.D. Meredith
- OP.3281/19/2/5: Highly contagious viruses: investigation of the excretion of SAT types of foot-and-mouth disease (FMD) virus from experimentally infected cattle. 1984. M.D. Gainaru
- OP.3281/19/2/6: Gamma irradiation for the inactivation of highly contagious viruses in animal products. 1986. G.R. Thomson

Poultry and fish diseases/Pluimvee- en vissiektes

POULTRY/PLUIMVEE

• Pathology/Patologie

- OP.3291/19/1/1: Diagnostics of disease conditions of poultry. 1981. F.W. Huchzermeyer
- OP.3291/19/2/2: Altitude disease ascites of broilers. 1985. F.W. Huchzermeyer

- OP.3291/19/2/3: Turkey malaria. 1985. F.W. Huchzermeyer
- OP.3291/19/2/4: Studies on the pathogenicity of rough and non-typable strains of *Escherichia coli* isolated from poultry. 1987. M.A. Kloryga
- OP.3291/19/2/5: A Survey of the susceptibility of smooth *E. coli* in commercial poultry flocks to commonly used anti-microbials. 1988. J.A. Cilliers

FISH/VIS

• Pathology/Patologie

- OP.3292/19/1/1: Diagnostics of disease conditions of fish. 1981. R.R. Bragg
- OP.3292/19/1/2: Trout virus survey. 1988. R.R. Bragg

Bacterial investigations/Bakteriese ondersoeke

BACTERIA/BAKTERIEë

• Pathology/Patologie

- OP.32101/19/1/1: Diagnostics of bacterial diseases of animals. 1981. Marijke M. Henton
- OP.32101/19/2/4: Bacteria: improvement of *E. coli* vaccines. 1982. P. Oberem
- OP.32101/19/2/8: A study of the occurrence of plasmids and lysogenic phages and its correlation with toxin production in *Clostridium perfringens* type D. 1986. G. Groenewald
- OP.32101/19/2/9: The development of a smooth avirulent *Salmonella typhimurium* vaccine. 1988. M.L. van der Walt

Protozoal investigations/Protosoa-ondersoeke

PROTOZOA/PROTOSOA

• Pathology/Patologie

- OP.32111/19/1/1: Diagnostics of protozoal and rickettsial diseases of animals. 1981. D.T. de Waal
- OP.32111/19/2/1: Protozoa: quality, safety and efficacy of Onderstepoort vaccines against bovine babesiosis. 1981. D.T. de Waal
- OP.32111/19/2/2: Protozoa: epidemiology of *Besnoitia besnoitii* infection in cattle. 1981. D.T. de Waal
- OP.32111/19/2/3: Protozoa: identity, distribution and transmission of *Theileria* spp. in South Africa. 1977. W.H. Stoltz
- OP.32111/19/2/6: Protozoa: in vitro cultivation of *Babesia* spp. with special reference to *Babesia bovis*. 1984. F.T. Potgieter
- OP.32111/19/2/7: Protozoa: a study of babesiosis in horses. 1984. D.T. de Waal
- OP.32111/19/3/1: Protozoa: the quality, safety and efficacy of Onderstepoort anaplasmosis vaccines. 1981. F.T. Potgieter
- OP.32111/19/3/2: Protozoa: transmission of *Anaplasma marginale* by ticks and biting insects. 1977. F.T. Potgieter
- OP.32111/19/3/3: The treatment of heartwater. 1988. P.T. Oberem
- OP.32111/19/3/4: Immunisation against heartwater by means of chemoprophylaxis. 1989. J.A. Olivier
- OP.32111/19/3/5: Immunisation against heartwater with a combination of *Cowdria ruminantium* stocks. 1989. J.L. du Plessis

Molecular biological investigations/Molekulêre biologiese ondersoeke

MACROMOLECULES/MAKROMOLEKULE

• Virology/Virologie

- OP.32/21/12/1/4: Macromolecules: cloning of jaagsiekte virus through genetic manipulation. 1982. E.S. Posnett
- OP.32/21/12/1/6: Production of monoclonal antibodies against jaagsiekte retrovirus antigens. 1985. D.F. York
- OP.32/21/12/1/7: Macromolecules: the distribution and role of lentiviruses in sheep in South Africa. 1986. D.W. Verwoerd

• Protozoology/Protosoölogie

- OP.32/21/13/1/1: Macromolecules: the construction and partial characterisation of genomic libraries of *Babesia* and *Anaplasma* DNA. 1985. R.E. Ambrosio
- OP.32/21/13/1/3: Macromolecules: the development of probes for the detection of *Anaplasma* in bovine blood. 1987. E.S. Visser
- OP.32/21/13/1/4: Macromolecules: the isolation and characterisation of the probes for the identification of *Babesia equi* and *Babesia caballi* in horses. 1987. E.S. Posnett
- OP.32/21/13/1/5: Macromolecules: the isolation and characterisation of *Cowdria ruminantium* nucleic acid probes. 1988. S.C. Wilkens

Biochemical investigations/Biochemiese ondersoeke

BIOCHEMICAL INVESTIGATIONS/BIOCHEMIESE ONDERSOEKE

• Virology/Virologie

- OP.32/31/12/1/7: The use of vaccinia virus expression vector for the neutralising antigen, protein P2 of bluetongue virus. 1987. Alberdina A. van Dijk
- OP.32/31/12/1/8: Biochemical investigations: an investigation of the composition and function of the virus specific tubules which are found in orbivirus infected cells. 1987. Alberdina A. van Dijk
- OP.32/31/12/1/9: Biochemical characterisation of equine encephalosis virus and the development of diagnostic genomic probes for the virus. 1987. G.J. Viljoen
- OP.32/31/12/1/10: The development and use of cloned genome segments as probes for the identification of horsesickness virus. 1987. C.W. Vroon
- OP.32/31/12/1/11: Preparation and characterisation of monoclonal antibodies to African horsesickness virus. 1987. W. van Wyngaardt
- OP.32/31/12/1/12: Biochemical investigation of the structure and function of a phosphorylated non-structural protein of bluetongue virus. 1986. S.J. Hall
- OP.32/31/12/1/13: An investigation of the composition and genetic variation of the group-specific antigen of bluetongue virus. 1987. M. Cloete
- OP.32/31/12/1/14: Identification of the nucleotide sequence coding for the neutralisation specific epitope or epitopes of bluetongue virus. 1987. N.T. van der Walt

Chemical pathology and poison chemistry/Chemiese patologie en gifstofchemie

POISONS/GIFSTOWWE

• Toxicology/Toksikologie

- OP.32/41/18/1/1: Poisons of and poisoning by cardiac glycosides from plants of the family Crassulaceae. 1981. L.A.P. Anderson

- OP.32141/18/1/2: Poisons of and poisoning caused by *Cynanchum* species. 1981. G.L. Erasmus
- OP.32141/18/1/3: Poisons of and poisoning caused by *Sarcostemma viminale*. 1984. L.A.P. Anderson
- OP.32141/18/1/4: Poisons of and poisoning caused by *Ornithogalum thyrsoides*. 1983. J. de V. du Toit
- OP.32141/18/1/5: An investigation of *Albizia tanganyicensis* poisoning. 1986. L.A.P. Anderson
- OP.32141/18/1/6: An investigation of *Lasiospermum bipinnatum* poisoning. 1986. L.A.P. Anderson
- OP.32141/18/2/1: Poisons of and poisoning caused by tremorgenic mycotoxins of *Aspergillus clavatus*. 1975. L.A.P. Anderson

AGRICULTURAL RESOURCE UTILISATION LANDBOUHULPBRONBENUTTING

RESOURCE RESEARCH/HULPBRONNAVORSING

Primary resources/Primêre hulpbronne

SOIL/GROND

• Soil science/Grondkunde

- GB.5111/32/1/3: Soil fertility - a basis according to which soils can be grouped. 1975. A.J. van der Merwe
- GB.5111/32/2/1: The isolation, identification, quantitative determination and chemical reactions of growth stimulating and inhibiting organic compounds in soil and crop residues of summer and small grains. 1980. P. de L. R. Swartz
- GB.5111/32/3/1: The distribution and properties of liming materials and waste products with reference to suitability for amelioration of RSA soils. 1979. H.C.H. Hahne
- GB.5111/32/3/2: Silicon-phosphorus-sesquioxide relationships with a view to amelioration of acid soils with silicate. 1979. H.C.H. Hahne
- GB.5111/32/3/4: Ad hoc mineralogical analyses and investigations. 1982. W.F.A. Kirsten
- GB.5111/32/3/5: Morphological and mineralo-chemical studies of some South African podzols and podzolised soils. 1982. L.C. Hawker
- GB.5111/32/3/7: The dynamics of neutralising agents of porous inert media and soil in a larger area. 1985. A.J. van der Merwe
- GB.5111/32/3/8: A study on the formation, characteristics and properties of disturbed surface layers on quartz grains and the influence thereof on the behaviour of sandy soils. 1989. J.N.J. Viljoen
- GB.5111/32/4/3: The quantitative description of the soil water regimes of selected crop ecotopes. 1985. M. Hensley
- GB.5111/32/5/1: The quantitative characterisation of a porous medium, e.g. soil. 1981. D.A. Russell
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Surveys and demarcation/Opnames en afbakening

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• *Ecology/Ekologie*

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- HK.5136/40/1/1: Other surveys: an investigation into the efficiency of study groups in Transvaal. 1984. C.H. de Waal

Irrigation development/Besproeiingsontwikkeling

IRRIGATION PLANNING/BESPROEIINGSBEPLANNING

• *Crop science/Gewaskunde*

- T.5141/30/1/1: Irrigation planning: the influence of row spacing and plant density on the yield of maize under trickle irrigation. 1986. W.F. van Wyk

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- D.5141/35/1/1: The collection of data relating to existing irrigation practices in the Fish River irrigation area. 1987. R.F.M. Childs

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- GB.5141/37/1/1: Evaluation of areas for irrigation development and farm layout on State Schemes. 1979. J. Myburgh
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RESOURCE UTILISATION RESEARCH (CROPS) HULPBRONBENUTTINGSNAVORSING (GEWASSE)

Field crops/Landgewasse

SUMMER GRAIN/SOMERGRAAN

- *Nutrition/Voeding*

- D.5211/05/1/1: Summer grain: NPK nutrition of maize at Dohne. 1978. R.S. Marr
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- D.5211/05/1/5: Summer grain: nutrition of maize-phosphorus carriers and lime in the Tsitsikamma area. 1988. R.S. Marr

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- T.5211/20/1/1: Summer grain: survey of fungus-growing termites on agronomic crops. 1977. H.H. Gouse

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- H.5211/30/2/3: Summer grain: soil tillage practices for maize on a Hutton and Avalon soil form in RHFA 6006 in the Highveld Region. 1986. P.J. Laubscher
- T.5211/30/1/1: Maize: the influence of between and within row spacing on soil water utilisation and yield under dryland conditions. 1988. I.D. Lamprecht
- V.5211/30/1/1: Summer grain: irrigation and nitrogen fertilisation studies with maize at Upington. 1985. A. van Schalkwyk
- V.5211/30/1/2: Summer grain: irrigation and nitrogen fertilisation studies with maize at Vaalharts. 1985. A. van Schalkwyk
- V.5211/30/1/3: Summer grain: maize production under different irrigation systems at Vaalharts. 1986. A. van Schalkwyk
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- H.5211/42/1/1: The development of a simulation type model to predict production of the more important summer grains in the Highveld Region. 1985. P.J. van Rooyen

SMALL GRAIN/KLEINGRAAN

• *Physiology/ Fisiologie*

- W.5212/03/1/1: Small grain: the biology of rufous brome (*Bromus diandrus*) in the Winter Rainfall Region. 1985. H.M. Ferreira

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- W.5212/05/1/1: Small grain: the influence of time and amount of application of nitrogen fertiliser on wheat production in the Winter Rainfall Region. 1980. J.W. Loubser
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- W.5212/21/1/1: Chemical weed control of different broad leaf and grass weeds in small grain production in the Winter Rainfall Region. 1974. J.W. Loubser
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- D.5214/30/1/4: Other field crops: crop rotation for chicory in the Eastern Cape. 1980. R.S. Marr
- V.5214/30/1/1: Other field crops: cotton production under different irrigation systems at Vaalharts. 1986. A. van Schalkwyk
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Garden crops/Tuingewasse

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• *Pests/Plae*

- W.5221/20/1/1: Tuber crops: the migratory habits of aphid vectors of potato viruses in the seed potato producing areas of the winter rain cropping area. 1976. S.S. Walters

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- *Physiology/Fisiologie*

- N.5222/03/1/1: Interactions between the stage of plant development and herbicide treatment in the expression of phytotoxic responses to phenoxyalkanoic herbicides. 1988. R.J. Bennet

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- W.5232/20/1/1: Distribution and movement patterns of the Cape sparrow *Passer melanurus* (Müller) - a problem bird of grapes in the irrigation areas of the Winter Rainfall Region. 1985. M.J.F. Jarvis
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RESOURCE UTILISATION RESEARCH (ANIMALS) HULPBRONBENUTTINGSNAVORSING (DIERE)

Ruminants/Herkouers

LARGE STOCK/GROOTVEE

- *Physiology/Fisiologie*

- D.5311/03/1/1: Large stock: hormonal status and calving percentage of beef cows and heifers in the sourveld. 1979. J.A. Erasmus

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- T.5311 03 1 2: Large stock: influence of different over-wintering feeding regimes on production and growth of beef cattle. 1971. S.D. Nieman
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- T.5311/03/1/4: Large stock: management of a dairy unit on a small farming unit utilising cultivated pastures. 1988. M.J. Meaker

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- N.5311/04/1/2: Oestrus and ovulation in mature female beef cattle as affected by changes in live mass. 1978. B.P. Louw
- N.5311/04/1/5: Large stock: the relationship between libido and mating activity in Zebu bulls. 1987. J.S. Crichton
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- D.5311/05/2/1: Large stock: the evaluation of kikuyu pastures for milk production. 1984. W.P. Henning
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- T.5311/07/1/2: Large stock: development and improvement of the Edelheer, Roodebos and Wesselsvlei breeding lines of the Bonsmara beef cattle race in the sour mixed bushveld at Roodeplaat. 1971. G. Marincowitz
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- N.5311/41/2/8: Large stock: management - the suckling behaviour of beef calves on intensive pastures at Cedara. 1988. I.B. Stewart
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- T.5311/41/1/3: Large stock: the potential and profit margins of weaner, tollie and ox production systems in the bushveld. 1963. C.J.F. Lüdemann
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- V.5311/41/2/1: Large stock: a weaner, long yearling and an ox production system with three beef cattle types on the veld of Vaalharts. 1988. H.S. Pottas
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SMALL STOCK/KLEINVEE

• Reproduction/Reproduksie

- K.5312/04/1/2: Investigation of retarded growth after weaning in Angora goats. 1987. P.R. King
- T.5312/04/1/1: Small stock: effect of energy, protein and NPN on the fertility of mutton sheep ewes. 1970. G. Marincowitz
- T.5312/04/2/1: Small stock: the sexual activity of Merino woolled sheep and their crosses. 1973. L. Bouwer
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- D.5312/05/1/1: Small stock: the relationship in the seasonal variation in the beta carotene of sourveld and the beta carotene levels of blood plasma in woolled sheep. 1983. P.J.L. Zeeman
- D.5312/05/1/2: Small stock: the influence of beta carotene supplementation on the reproduction of lactating ewes. 1983. J.A. Erasmus
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- W.5416/03/1/1: Drought fodder crops: influence of season, genotype and soil type on the palatability and chemical composition of *Atriplex nummularia* in the Winter Rainfall Region. 1987. S.A. Barnard

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Veld

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- NW.5421/27/1/1: Game ranching decision support in respect of stocking rates and species. 1988. D.D. Berliner

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• *Crop science/ Gewaskunde*

- NW.5431/30/1/1: Establishment practices for annual and perennial cultivar of *Cajanus cajan*. 1987. C. Sutherland

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- *Management/Bestuur*

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RESOURCE UTILISATION RESEARCH (FARMING SYSTEMS) HULPBRONBENUTTINGSNAVORSING (BOERDERYSTELSELS)

Farming enterprises/Boerderyvertakings

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- D.5513/41/1/6: The compilation of a manual to promote mixed farming production techniques in the Dohne sour grassveld. 1987. M.L. Bode
- N.5513/41/1/1: Mixed farming: the development of a farm planning manual for use in Natal Region. 1986. L.D. Papenfus
- W.5513/41/1/1: Mixed crop and animal production practices for optimum land utilisation in the Swartland. 1973. J.D. Langenhoven
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AGRICULTURAL PRODUCTION ECONOMY RESEARCH LANDBOUPRODUKSIE-EKONOMIENAVORSING

Macro resource economy/Makrohulpbronekonomie

PRODUCTION FACTOR STUDIES/PRODUKSIEFAKTORSTUDIES

• *Production economics/Produksie-ekonomie*

- PE.5611/48/1/1: Production factor studies: the determination of a remuneration for the management function in agricultural concerns. 1980. J.S.G. Joubert
- PE.5611/48/1/3: Production factor studies: an agricultural economic evaluation of alternative irrigation systems in the Orange-Vaal irrigation area. 1987. E.J. du Toit
- PE.5611/48/2/1: Production factor studies: the determination of the value of agriculture land in the RSA. 1976. B.D.T. Janse van Rensburg
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- PE.5612/48/1/1: Structural studies: the development of an alternative methodology for the determination of minimum farm size. 1982. D. Armer
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Farm business management/Plaasbedryfsleer

BUSINESS RESULTS/BEDRYFSRESULTATE

• *Production economics/Produksie-ekonomie*

- PE.5621/48/1/3: Economical investigation into game farming in South Africa. 1987. J. Behr

- PE.5621/48/1/5: Structural studies: quantification of relationships between input and output and expected economic returns of crop production with variable water supply. 1986. T. Virag
- PE.5621/48/2/2: Business results and the production cost of wheat and other branches of farming in the Eastern Free State summer rain cropping areas. 1977. D.J. Mulder
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• *Production economics/Produksie-ekonomie*

- D.5622/48/1/1: Management techniques: the development and provision of agricultural economic computer models for extension personnel in the East Coast and Albany subregions. 1987. J.F. Els
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- PE.5622/48/8/2: Management techniques: the use of income and cost budgets for effective planning of livestock and crop enterprises in the Eastern Cape Region. 1973. C.J. Potgieter
- PE.5622/48/9/1: Management techniques: the use of income and cost budgets for effective planning of livestock and crop enterprises in the Transvaal Region. 1973. D.C. du Toit
- PE.5622/48/9/2: Management techniques: the use of income and cost budgets for effective planning of livestock and crop enterprises in the summer rain cropping area of the Highveld Region. 1973. P.F. du Plessis

ENTERPRISE RELATIONSHIPS/BEDRYFSVERHOUDINGS

• *Production economics/Produksie-ekonomie*

- PE.5623/48/1/5: Enterprise relationship: cost benefit analysis for the supply of irrigation water out of the Theewaterskloof Dam to the Eersteriviervallei. 1986. J.M. van Zyl
- PE.5623/48/1/6: The optimum choice of agricultural enterprises in identified regions in the Swartland. 1988. R.J. Nowers
- PE.5623/48/2/2: Enterprise relationship: the introduction of long-term pasture crops in sheep production systems in the central grassveld of the Free State Region. 1982. A. de K. Marais
- PE.5623/48/2/5: Assessment of the profitability of irrigated pastures for livestock farming in the highland sourveld regions of Natal. 1984. A. de K. Marais
- PE.5623/48/2/6: Some economic aspects of fertiliser usage in maize production in Natal. 1986. C.G. Berry
- PE.5623/48/2/7: Enterprise relationship: a long-term economic evaluation of sheep production systems at different stocking rates on climax grasslands in the central Free State. 1986. A. Odendaal
- PE.5623/48/2/8: Enterprise relationship: an examination of the economic and financial causes of non-optimal utilisation of natural pastures in the magisterial district of Gordonia. 1988. J.J. Kamfer

- PE.5623/48/3/1: Enterprise relationship: the economic evaluation of the utilisation of fodder crops with Merino sheep in the Fish River Valley. 1982. S.S. Hansen
- PE.5623/48/3/2: Enterprise relationship: the economic evaluation of development studies of components of dry-grass bushveld grazing in the Eastern Cape. 1976. C.J. Potgieter
- PE.5623/48/3/3: Enterprise relationship: the economic evaluation of the potential pastures in respect of small stock in the eastern coastal areas of the Eastern Cape. 1976. C.J. Potgieter
- PE.5623/48/3/4: Enterprise relationship: the development and evaluation of a profitable livestock farming system for the Valley Bushveld areas in good condition in the Eastern Cape Region. 1983. C.J. Potgieter
- PE.5623/48/3/5: Enterprise relationship: the development and evaluation of a profitable livestock farming system for the Valley Bushveld in deteriorated condition of the Eastern Cape Region. 1983. C.J. Potgieter
- PE.5623/48/3/6: Enterprise relationship: the development, management and evaluation of adapted livestock farming system Campagna in the high rainfall sourveld areas of the Eastern Cape. 1983. C.J. Potgieter
- PE.5623/48/4/1: Enterprise relationship: wintering of woolled sheep and other livestock in the northern Drakensberg grazing region. 1982. H.A. Minnaar
- PE.5623/48/4/3: Enterprise relationship: the influence of different feeding strategies on the economic efficiency of beef cattle in the summer rain cropping areas. 1983. J.J. de Bruyn
- PE.5623/48/4/5: An economic analysis of dairy enterprises and their financial roles in the farming structure of mixed farming in the summer rain cropping area. 1984. P.J. Cornelius
- PE.5623/48/4/7: Enterprise relationship: strategy for production continuation and renewal of citrus and subtropical orchards in the bushveld area. 1984. D.C. du Toit
- PE.5623/48/4/9: Enterprise relationship: the economic evaluation of the RHFA concept with respect to the minimising of risk and the determination of land values. 1986. J.J. de Bruyn
- PE.5623/48/4/10: Enterprise relationship: the influence of different feeding strategies on the economic efficiency of small stock farming in the summer rain cropping areas. 1986. P.F. du Plessis
- PE.5623/48/4/11: The economic justification of the introduction/expansion of livestock enterprises in stead of crop production on marginal soils. 1988. F.J. de Jager

SOIL CONSERVATION RESEARCH/GRONDBEWARINGSNAVORSING

Soil conservation/Grondbewaring

EROSION/EROSIE

• *Situation analysis/Situasiebepaling*

- V.5711/35/1/1: Erosion: investigation of the functional efficiency of subsidised waterways in the middle Free State subregion. 1985. S.J. van Reenen

• *Conservation studies/Bewaringstudies*

- D.5711/38/1/1: Erosion: the determination of soil losses associated with various tillage practices on various soil series established to pineapples in the East London district. 1982. B. Denyer
- D.5711/38/1/2: Erosion: the determination of soil losses associated with various tillage practices and land use on soil series at Alexandria. 1983. B. Denyer

- D.5711/38/1/3: The determination of soil losses associated with various tillage practices and land use on various soil series in Humansdorp Extension Ward. 1986. B. Denyer
- D.5711/38/1/4: Erosion: the correlation of soil loss figures obtained from natural run-off plots and rainfall simulator trials on pineapple ridges. 1985. B. Denyer
- D.5711/38/2/2: Erosion: the effect of various small structures in eroded watercourses in the high rainfall sourveld. 1985. E. Marx
- D.5711/38/2/3: Erosion: the effect of small structures in eroded watercourses in the bushveld areas. 1984. G.M. Bicknell
- D.5711/38/2/4: The influence of small conservation structures and re-established plant cover in the eroded low lying areas in the Henderson semi-palatable bushveld. 1987. P.C. Griffiths
- D.5711/38/4/1: To determine the maximum safe length and fall in ridges as well as spacing of contours on various pineapple land lay-outs associated with various tillage practices and soil series in order to combat erosion. 1985. B. Denyer
- D.5711/38/5/1: Erosion: the effect of burning and post-burn grazing practices on run-off and soil loss in the Dohne sour grassveld. 1988. M.L. Bode
- N.5711/38/1/1: Erosion studies using natural run-off plots. 1985. W.B. Russell
- N.5711/38/1/2: Studies using a rainfall simulator and natural run-off plots to quantify soil losses from veld. 1982. R.P. Simms
- N.5711/38/1/3: Erosion and run-off studies on pineapple lands in Zululand. 1987. W.B. Russell
- V.5711/38/1/1: Erosion: investigation of adapted grass covers for waterways in RHFA 4053. 1985. P.J. Knoester
- V.5711/38/2/1: Erosion: water run-off control planning of the Immigrant area in the Petrusburg Extension Ward. 1985. F.J. Smit
- V.5711/38/2/2: Erosion: water run-off control planning of subcatchment area 3 of the Korannaberg catchment area in Excelsior district in the Brandfort Extension Ward. 1985. S.J. van Reenen
- V.5711/38/2/3: Erosion: water run-off control planning of the Rondas area in the Brandfort Extension Ward. 1986. C.S. van Niekerk
- V.5711/38/2/4: Erosion: water run-off control planning of the Spioenheuvel area in the Boshof district in the Kimberley Extension Ward. 1987. J.H. Mulder
- V.5711/38/3/1: Erosion: investigation of the functional efficiency of different types of small conservation structures in eroded areas in dongas and gullies in the Edenburg Extension Ward. 1985. S. Brink
- V.5711/38/3/2: Erosion: investigation of the functional efficiency of different types of small conservation structures in dongas and gullies in the Postmasburg Extension Ward. 1985. J. Weyers

• *Engineering/Ingenieurskunde*

- LI.5711/51/1/1: Engineering aspects of soil erosion: aspects of gully erosion. 1983. P.J. Strumpher
- LI.5711/51/1/2: Engineering aspects of soil erosion: aspects regarding soil losses. 1983. P. McPhee

DRAINAGE/DREINERING

• *Agrohydrology/Agrohidrologie*

- V.5712/34/1/1: The planning and implementation of drainage systems on waterlogged and salinised irrigation lands in the Vaalharts irrigation area. 1985. J.H. Mulder
- V.5712/34/1/2: The planning and implementation of drainage systems on waterlogged and salinised irrigation lands in the Douglas Extension Ward. 1985. J.H. Mulder

Planning of areas/Beplanning van gebiede

FARM PLANNING/PLAASBEPLANNING

• *Agrohydrology/Agrohidrologie*

- N.5831/34/1/1: Farm planning: run-off control planning in the Howick Extension Ward. 1979. M.G. Price
- N.5831/34/1/2: Farm planning: run-off control planning in the Greytown Extension Ward. 1979. R.C. Richardson
- N.5831/34/1/3: Farm planning: run-off control planning in the Ixopo Extension Ward. 1979. A.D. Simpson
- N.5831/34/1/4: Farm planning: run-off control planning in the Pongola Extension Ward. 1979. R.J. Dicks
- N.5831/34/1/5: Farm planning: run-off control planning in the Kokstad Extension Ward. 1979. D.B. Austin
- N.5831/34/1/6: Farm planning: run-off control planning in the Richmond Extension Ward. 1979. E.M.F. McAllister
- N.5831/34/1/7: Farm planning: run-off control planning in the Newcastle Extension Ward. 1979. M.P. Wentzel
- N.5831/34/1/8: Farm planning: run-off control planning in the Vryheid Extension Ward. 1979. R.J. Dicks
- N.5831/34/1/9: Farm planning: run-off control planning in the Estcourt Extension Ward. 1979. S.K. Armour
- N.5831/34/1/10: Farm planning: run-off control planning in the Dundee Extension Ward. 1979. P.P. Kloppers
- N.5831/34/1/11: Farm planning: run-off control planning in the Pietermaritzburg Extension Ward. 1979. P.J.D. Nicholson
- N.5831/34/1/12: Farm planning: run-off control planning in the Ladysmith Extension Ward. 1979. K.W. Watkinson
- T.5831/34/1/2: Farm planning: run-off control of the north-eastern Springbok Flats area. 1980. J. Bellingham
- T.5831/34/1/3: Farm planning: run-off control in the south-eastern area of the Transvaal Region. 1976. M.M. Struthers
- T.5831/34/1/4: Farm planning: run-off control in the middle Transvaal area of the Transvaal Region. 1979. K.P. de Beer
- T.5831/34/1/5: Farm planning: run-off control in the Annysspruit area of the south-eastern Transvaal area. 1975. J.C. Nel
- T.5831/34/1/6: Farm planning: run-off control in the Klein-Komati area of the south-eastern Transvaal. 1975. J.C. Mouton
- T.5831/34/1/11: Farm planning: the design of a water run-off control system for the Strydom block area - Lowveld, Komatiepoort. 1975. M.V. Wattrus
- T.5831/34/1/12: Farm planning: run-off control in the Sabie Valley area - the design of a water run-off control system in the Sabie Valley and White River. 1975. M.V. Wattrus
- T.5831/34/1/13: Farm planning: run-off control in the Western Transvaal area (Syferbult) of the Transvaal Region. 1985. J.T. Nel
- T.5831/34/2/1: Farm planning: run-off control in the Badplaaskom area of the south-eastern area of the Transvaal Region. 1975. H.P. den Dulk
- T.5831/34/2/2: Farm planning: run-off control in the Western Transvaal (Bokfontein) area of the Transvaal Region. 1986. C.J. Meiring

T.5831/34/2/3: Run-off control in the Western Transvaal area (Koedoeshoop West) of the Transvaal Region. 1986. G.P. Engelbrecht

• *Management/ Bestuur*

- D.5831/41/1/1: Planning of farms within the Alexandria magisterial district to promote the efficient conservation of natural resources. 1984. A.E.O. Botha
- D.5831/41/1/2: Planning of farms with regard to veld utilisation and resource conservation within the Elliot Extension Ward to promote the efficient utilisation and conservation of natural resources. 1985. E. Marx
- D.5831/41/1/3: Farm planning within the Barkly East Extension Ward to promote efficient utilisation and conservation of natural resources. 1985. J.S.J. Jordaan
- D.5831/41/1/4: Farm planning of farms within the Adelaide Extension Ward to promote efficient utilisation and conservation of natural resources. 1985. G.M. Bicknell
- D.5831/41/1/5: Planning of farms within the Bathurst magisterial district to promote the efficient utilisation and conservation of natural resources. 1985. B.I. Hill
- D.5831/41/1/6: Planning of farms within the Tarkastad magisterial district to promote the efficient utilisation and conservation of agricultural resources. 1983. W.J.M. Els
- D.5831/41/1/7: Planning of farms in the Komga magisterial district to promote the efficient utilisation and conservation of the natural resources. 1984. C.J. Bradfield
- D.5831/41/1/8: Planning of farms in the Stutterheim Extension Ward to promote the efficient utilisation and conservation of the natural resources. 1984. P.C. Griffiths
- D.5831/41/1/9: Planning of farms within the Sterkstroom magisterial district to promote the efficient utilisation and conservation of the natural resources. 1983. J.H. Fourie
- D.5831/41/1/10: Planning of farms within the Albany magisterial district to promote efficient utilisation and conservation of natural resources. 1986. W.J. Penny
- D.5831/41/1/11: Planning of farms with regard to veld utilisation and resource conservation within the Humansdorp Extension Ward to promote the efficient utilisation and conservation of natural resources. 1985. J.P. van Zyl
- D.5831/41/1/12: Planning of farms within the Molteno magisterial district (Dordrecht Extension Ward) to promote efficient utilisation and conservation of the natural resources. 1985. J.C. van der Walt
- D.5831/41/1/13: Planning of farms within the Uitenhage and Kirkwood magisterial districts to promote the efficient utilisation and conservation of the natural resources. 1985. C.S. van R. Müller
- D.5831/41/1/14: Planning of farms within the Queenstown magisterial district to promote the efficient utilisation and conservation of the natural resources. 1983. W.J.M. Els
- D.5831/41/1/15: Planning of farms in the Port Elizabeth magisterial district of the eastern seaboard area. 1986. R.P. Laing
- D.5831/41/1/16: Planning of farms within the Aliwal North Extension Ward to promote efficient utilisation and conservation of the natural resources. 1985. D.T. Bezuidenhout
- D.5831/41/2/1: Run-off control planning of farms in the sub-catchment area No. 10900104 in the Humansdorp Extension Ward. 1984. J.P. van Zyl
- D.5831/41/2/2: Run-off control planning of farms in the Zuney Valley, sub-catchment area No. 14200200. 1984. A.E.O. Botha
- D.5831/41/2/3: Farm planning: area run-off control planning in catchment areas No. 041308, 041309 and 041312 within the Barkly East Extension Ward. 1985. J.S.J. Jordaan
- D.5831/41/2/4: Farm planning: area run-off control planning in sub-catchment No. 17500400 in the Elliot Extension Ward. 1985. E. Marx
- D.5831/41/2/5: Run-off control planning of farms in the Baviaans River catchment area - drainage region No. 1560 - Bedford magisterial district. 1985. G.M. Bicknell
- D.5831/41/2/6: Area run-off control planning of farms in the Elands River Valley sub-catchments No 12100100 and 11700300. 1985. C.S. van R. Müller

- D.5831/41/2/7: Farm planning: stabilising of eroded watercourses in upper Heuningklip River - sub-catchment area 1730/02/04. 1983. J.E. Aspinall
- D.5831/41/2/8: Farm planning: run-off control planning in a portion of the sub-catchment area No. 04130500 (Bossielaagte) situated in the Lady Grey magisterial district. 1985. D.T. Bezuidenhout
- D.5831/41/2/9: Water run-off control planning of farms in the area demarcated as Upper-Coerney, sub-catchment No. 13401501 in the Paterson area. 1985. R.P. Laing
- D.5831/41/2/11: Area run-off control planning of farms in the Buyskloof Valley, sub-catchment No. 14200100, in the eastern seaboard area. 1986. A.E.O. Botha
- D.5831/41/2/12: Farm planning: maintenance and improvement of existing run-off control plans on cultivated lands in the catchment areas No. 041308, 041309 and 041312 within the Barkly East Extension Ward. 1985. J.S.J. Jordaan
- D.5831/41/2/13: Farm planning: run-off control planning in the sub-catchment area 15430101 (Vrolikskraal) situated in the Molteno magisterial district. 1985. J.C. van der Walt
- D.5831/41/2/14: Farm planning: water run-off control - improvement and maintenance of existing contour systems in the Elands River catchment area. 1986. I. du P. Barlow
- D.5831/41/2/15: Farm planning: stabilising of eroded watercourses in Bamboeshoek, sub-catchment area No. 17300201. 1984. J.H. Fourie
- D.5831/41/2/16: Area run-off control planning of farms in the sourveld area in the Humansdorp Extension Ward of the Karoo and arid areas. 1986. E.C. Kieck
- D.5831/41/2/17: Area run-off control planning of farms in the Upper Krom River area in the Humansdorp Extension Ward of the eastern seaboard area. 1986. E.C. Kieck
- D.5831/41/2/18: Farm planning: area run-off control planning of irrigation lands in the Hankey magisterial district. 1986. R.P. Laing
- D.5831/41/2/19: Water run-off control planning of all pineapple farms in the East London Extension Ward. 1985. I.D. Scholtz
- D.5831/41/2/20: Farm planning: area run-off control planning of irrigation in the proposed Kabeljou irrigation area in the Humansdorp magisterial district. 1987. E.C. Kieck
- D.5831/41/2/21: Farm planning: area run-off control planning of lands in the Blue River Valley. 1988. C.J. Bradfield
- D.5831/41/2/22: Farm planning: water run-off control - determining the most suitable grass(es) to be used in waterways and watercourses in the Algoa subregion. 1988. I. du P. Barlow

ENTREPRENEUR DEVELOPMENT ONDERNEMERSONTWIKKELING

EXTENSION SCIENCE INVESTIGATIONS VOORLIGTINGKUNDIGE ONDERSOEKE

Resources and technology/Hulpbronne en tegnologie

MANAGEMENT FACTORS/BESTUURSAKTORE

- *Persuasion/Oorreding*

- T.6114/39/1/5: Management factors: the persuasion of farmers to optimal resource utilisation in the Koedoesrand area of northern Transvaal in the Transvaal Region. 1976. S.W. Burger

MAN/MENS

- *Situation analysis/Situasiebepaling*

- H.6115/35/1/1: Factors that influence the under-achievement of first-year students at Potchefstroom College of Agriculture. 1983. L.I. de Waal

- *Extension science/Voorligtingkunde*

- H.6115/40/2/1: Man: study group participation to agricultural development in the Lichtenburg subregion. 1985. M.M. Grobbelaar
- N.6115/40/1/1: Human potential in relation to optimum land use of farmers in the Underberg Extension Ward. 1974. D.M. Rix

RUN-OFF CONTROL/AFLOOPBEHEER

- *Agrohydrology/Agrohidrologie*

- T.6118/34/1/6: Run-off control in the Klein Komati area of the south-eastern Transvaal. 1975. J.C. Mouton -
- T.6118/34/1/10: Run-off control: the design of a water run-off control system in the Bokpoort target area in Potgietersrus. 1975. J. Bellingham
- T.6118/34/1/11: Run-off control: the design of a water run-off control system for the Strydom block area - Lowveld, Komatipoort. 1975. M.V. Watrus
- T.6118/34/1/12: Run-off control in the Sabie Valley area - the design of a water run-off control system in the Sabie Valley, Witrivier. 1975. M.V. Watrus
- T.6118/34/2/1: Run-off control in the Badplaaskom area of the south-eastern Transvaal area of the Transvaal Region. 1975. J.C. Mouton

COMMUNICATION/KOMMUNIKASIE

- *Extension science/Voorligtingkunde*

- N.6119/40/1/1: The use of agricultural literature in communicating information to farmers in the Natal Region. 1982. Marion A. Abbott
- W.6119/40/1/1: Communication: an extension science investigation into the effectiveness of the table grape block competition in the Hex River Valley. 1985. G.G. van der Merwe

PROGRAMMED EXTENSION/GEPROGRAMMEERDE VOORLIGTING

Resource utilisation/Hulpbronbenutting

STOCK AND GAME FARMING/VEE- EN WILDBOERDERY

• *Situation analysis/Situasiebepaling*

- D.6211/35/2/1: Stock and game farming: potential studies in the "Duneveld" farming area of the Riversdale Extension Ward. 1988. J.W. du Preez

• *Evaluation/Evaluasie*

- D.6211/37/1/1: Stock and game farming: to demonstrate the utilisation and control of tree and shrub species in the humid grass/bush communities of the Bathurst Extension Ward. 1987. P.G. King
- D.6211/37/1/2: Stock and game farming: to assess vegetation change in the Alexandria ward due to the aerial application of a herbicide to *Acacia karroo*. 1986. A.E. du Plessis

• *Persuasion/Oorreding*

- D.6211/39/1/1: Stock and game farming: the persuasion of farmers to promote optimal pasture utilisation and animal production in the Queenstown Extension Ward. 1984. L.P.J. Swart
- D.6211/39/1/2: Stock and game farming: the persuasion of farmers to promote optimal pasture utilisation and animal production in the Bedford magisterial district. 1986. J.B. Marais
- D.6211/39/1/3: Stock and game farming: the persuasion of farmers to promote optimal pasture utilisation and animal production in the Albany magisterial district. 1986. J.L. Clacey
- D.6211/39/1/4: Stock and game farming: to train farmers in the Adelaide and Bedford magisterial districts to subjectively assess veld condition in the False Thornveld. 1987. J.B. Marais
- D.6211/39/1/5: Stock and game farming: the persuasion of farmers to promote optimal pasture utilisation and animal production in the Alexandria Extension Ward. 1986. A.E. du Plessis
- D.6211/39/1/6: Stock and game farming: training of collaborators and extension officers in the Eastern Cape Region to achieve optimum milk production. 1986. P.J. Olivier
- D.6211/39/1/7: Stock and game farming: promotion of adopted stock farming in the Valley Bushveld of the Uitenhage Extension Ward. 1984. L.O. Grobler
- D.6211/39/1/8: Stock and game farming: persuasion of farmers in the Port Elizabeth Extension Ward to achieve optimum pasture and animal production. 1987. J.B.C. Kilfoil
- D.6211/39/1/9: Stock and game farming: training of farmer collaborators and extension staff in the Eastern Cape Region to promote optimum small stock production. 1987. J.C. Scheltema
- D.6211/39/1/10: Stock and game farming: the persuasion of farmers in the Thomas River conservation district to control and eradicate silver and black wattle. 1986. A.M. Grenfell
- D.6211/39/1/11: Stock and game farming: the persuasion of farmers to promote optimal pasture utilisation and animal production in the Stutterheim Extension Ward. 1986. A.M. Grenfell
- D.6211/39/1/12: Stock and game farming: the determination of veld grazing utilisation practices and farmer's knowledge and perceptions regarding these veld management practices in the King Williams Town and Komga districts. 1985. W.E. Ristow
- D.6211/39/1/13: Stock and game farming: the persuasion of farmers to promote optimal pasture utilisation and animal production in the King William's Town and Komga districts. 1986. W.E. Ristow

- D.6211/39/1/14: Stock and game farming: the persuasion of farmers to promote optimal pasture utilisation and animal production in the Humansdorp Extension Ward - high potential agricultural area. 1987. F.J. Weitz
- D.6211/39/1/15: Stock and game farming: the persuasion of farmers to promote optimal pasture utilisation and animal production in the Humansdorp Extension Ward - sourveld. 1987. F.J. Weitz
- D.6211/39/1/16: Stock and game farming: the persuasion of farmers to achieve optimum grazing utilisation and animal production in the Dordrecht Extension Ward. 1986. D.W. Schoeman
- D.6211/39/1/17: Stock and game farming: the persuasion of farmers to promote optimal veld utilisation and animal production in the Elliot Extension Ward. 1987. G.R. Morgan
- D.6211/39/1/18: Stock and game farming: the persuasion of farmers to promote optimal maize production in the Elliot Extension Ward. 1987. G.R. Morgan
- D.6211/39/1/19: Stock and game farming: the persuasion of farmers to achieve optimal pasture utilisation and animal production in the Elliot Extension Ward. 1987. G.R. Morgan
- D.6211/39/1/20: Stock and game farming: the persuasion of farmers to achieve optimum pasture utilisation and animal production in the Aliwal North Extension Ward. 1986. O.V. Loest
- D.6211/39/2/1: Stock and game farming: promotion of adapted stock farming in the Valley Bushveld of the Uitenhage Extension Ward. 1984. L.O. Grobler
- K.6211/39/1/1: Stock and game farming: persuasion of farmers to apply the group camp approach of veld management in the Extension Ward of Graaff-Reinet. 1985. J.G. Theron
- K.6211/39/1/2: Stock and game farming: persuasion of farmers to apply the group camp approach of veld management in the Cradock Extension Ward. 1985. P.S. van Heerden
- K.6211/39/1/3: Stock and game farming: persuasion of farmers to practise the group camp approach of veld management in the Burgersdorp Extension Ward. 1985. J.H. Spoelstra
- K.6211/39/1/4: Stock and game farming: persuasion of farmers to practise the group camp approach of veld management in the Colesberg Extension Ward. 1985. M. van Niekerk
- K.6211/39/1/5: Stock and game farming: persuasion of farmers to practise the group camp approach of veld management in the De Aar Extension Ward. 1985. N. Wilson
- K.6211/39/1/6: Stock and game farming: persuasion of farmers to practise the group camp approach of veld management in the Middelburg Extension Ward. 1985. J.D. Blom
- K.6211/39/1/7: Stock and game farming: persuasion of farmers to practise the group camp approach of veld management in the Calvinia Extension Ward. 1985. N. Nortje
- K.6211/39/1/8: Stock and game farming: persuasion of farmers to practise the group camp approach of veld management in the Carnarvon Extension Ward. 1985. G.Z.J. Barnard
- K.6211/39/1/9: Stock and game farming: persuasion of farmers to practise the group camp approach of veld management in the Kenhardt Extension Ward. 1985. J.J. Zandberg
- K.6211/39/1/10: Stock and game farming: persuasion of farmers to practise the group camp approach of veld management in the Prieska Extension Ward. 1985. D.J. Roux
- K.6211/39/1/11: Stock and game farming: persuasion of farmers to practise the group camp approach of veld management, Beaufort West Extension Ward. 1986. A.J. Wiid
- K.6211/39/1/12: Stock and game farming: persuasion of farmers to practise the group camp approach of veld management, Fraserburg Extension Ward. 1986. I.J. van der Merwe
- K.6211/39/2/1: Stock and game farming: persuasion of farmers to introduce drought fodder crops in the farming systems in the Graaff-Reinet Extension Ward. 1984. J.G. Theron
- K.6211/39/2/2: Stock and game farming: persuasion of farmers to establish drought fodder crops in the Colesberg Extension Ward. 1985. M. van Niekerk
- K.6211/39/2/3: Stock and game farming: persuasion of farmers to establish drought fodder crops in the De Aar Extension Ward. 1985. W.H. van Staden
- K.6211/39/2/4: Stock and game farming: persuasion of farmers to establish drought fodder crops in the Middelburg Extension Ward. 1985. J.D. Blom

- K.6211/39/2/5: Stock and game farming: persuasion of farmers to introduce drought fodder crops in the farming systems in the Calvinia Extension Ward. 1985. N. Nortje
- K.6211/39/2/6: Stock and game farming: persuasion of farmers to introduce drought fodder crops in the farming systems in the Carnarvon Extension Ward. 1985. G.Z.J. Barnard
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- N.6211/41/1/1: Stock and game farming: analysis of beef production management systems in the Underberg Extension Ward. 1985. C.M. Allan
- N.6211/41/1/2: Stock and game farming: the analysis of stock and game management systems on veld in the Pongola Extension Ward. 1986. D.M. Gammon

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- N.6211/42/1/1: Stock and game farming: development of a beef feeding simulator programme. 1975. B.P. Louw
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CROP FARMING/SAAIBOERDERY

- *Chemical control/Chemiese beheer*

- N.6212/21/1/1: Crop farming: insect pests of maize and their control. 1986. R.A. Bell

- *Persuasion/Oorreding*

- K.6212/39/2/1: Crop farming: persuasion of farmers to practise optimal irrigation management and techniques in the Cradock Extension Ward. 1984. P.S. van Heerden
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- *Persuasion/Oorreding*

- D.6213/39/1/1: Mixed farming: to persuade crop farmers in the Alexandria Extension Ward to adopt optimal crop production systems. 1986. A.E. du Plessis
- D.6213/39/1/2: Mixed farming: to persuade farmers in the Alexandria ward to implement the water run-off control plans drawn up for their farms. 1987. A.E. du Plessis
- D.6213/39/1/3: Mixed farming: the training of extension personnel in the east coast and central subregions with regard to economic principles and concepts and their practical application. 1987. J.F. Els
- D.6213/39/1/4: Mixed farming: to persuade landowners to effectively protect their lands which are situated above the Gamtoos State Water Scheme and for which run-off control programmes were served. 1987. H.J. Smith

- D.6213/39/1/5: Mixed farming: optimal resource development of the irrigation area in the Hankey magisterial district. 1987. H.J. Els
- H.6213/39/1/1: Persuasion of farmers with mixed farming enterprises in the Bethlehem Extension Ward in order to promote optimal land utilisation. 1981. J.H. de Klerk
- H.6213/39/1/2: Persuasion of farmers with mixed farming enterprises in the Harrismith Extension Ward in order to promote optimal land utilisation. 1983. J.T. van Rooyen
- H.6213/39/1/3: Persuasion of farmers with mixed farming enterprises in the Kroonstad Extension Ward in order to promote optimal land utilisation. 1981. P.J. van Wyk
- H.6213/39/1/4: Persuasion of farmers with mixed farming enterprises in the Bothaville Extension Ward in order to promote optimal land utilisation. 1979. J.I. de V. Burger
- H.6213/39/1/5: Persuasion of farmers with mixed farming enterprises in the Parys Extension Ward in order to promote optimal land utilisation. 1981. A.G.H. Kotze
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- H.6213/39/1/9: Persuasion of farmers with mixed farming enterprises in the Wolmaransstad Extension Ward in order to promote optimal land utilisation. 1986. A.J. Loretz
- H.6213/39/1/10: Persuasion of farmers with mixed farming enterprises in the Potchefstroom Extension Ward in order to promote optimal land utilisation. 1986. J.J. Steyn
- H.6213/39/1/11: Persuasion of farmers with mixed farming enterprises in the Vrede Extension Ward in order to promote optimal land utilisation. 1987. M.J. Marais
- H.6213/39/1/12: Persuasion of farmers with mixed farming enterprises in the Standerton Extension Ward in order to promote optimal land utilisation. 1987. J.A. Rafferty
- H.6213/39/1/13: Persuasion of farmers with mixed farming enterprises in the Frankfort Extension Ward in order to promote optimal land utilisation. 1987. P.J. Smith
- H.6213/39/1/14: Persuasion of farmers with mixed farming enterprises in the Schweizer Reneke Extension Ward in order to promote optimal land utilisation. 1987. A.M. Potgieter
- N.6213/39/1/1: The promotion of optimum production based on resource planning in the Pietermaritzburg Extension Ward. 1986. G. McGrath
- T.6213/39/1/1: Mixed farming: the persuasion of farmers to practise optimal resource utilisation in the high rainfall sourveld area of Belfast. 1985. A. van Deventer
- T.6213/39/2/1: Mixed farming: situation analysis of the irrigation practices in the Groblersdal Extension Ward. 1986. M.G. du Toit
- T.6213/39/3/1: Mixed farming: situation analysis of the peach industry in the Silverton Extension Ward. 1986. J.B. Stevens
- T.6213/39/3/2: Mixed farming: determination of a benchmark of the peach industry by means of case studies in the Silverton Extension Ward. 1986. J.B. Stevens
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- V.6213/39/1/4: Mixed farming: the persuasion of demonstrator farmers to determine the grazing potential of grazing capacity zones in the Mafeking Extension Ward. 1985. W. Goldblatt

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• *Norm studies/Normstudies*

- D.6213/50/1/1: Mixed farming: collection and processing of pasture and animal production data for use in dairy production. 1986. P.J. Olivier
- D.6213/50/1/2: Mixed farming: collection and processing of pasture and animal production data for use in small stock production. 1986. J.C. Scheltema

FRUIT FARMING/VRUGTEBOERDERY

• *Situation analysis/Situasiebepaling*

- N.6214/35/1/1: Situation analysis: bananas in the Port Shepstone Extension Ward. 1983. E.H. Gevers

• *Persuasion/Oorreding*

- T.6214/39/1/1: Fruit farming: the persuasion of guava farmers to optimal resource utilisation in the irrigation areas of the Lowveld. 1982. J.J. Kruger
- T.6214/39/1/2: The persuasion of banana producers to optimal resource utilisation in the irrigation areas of the Transvaal Lowveld. 1983. C.C. Engelbrecht
- W.6214/39/1/1: Fruit farming: persuasion of farmers in the Langkloof farming area to implement recommended soil-plant combinations, correct soil preparation and established techniques. 1985. W.S. van der Merwe

VEGETABLE FARMING/GROENTEBOERDERY

• *Persuasion/Oorreding*

- W.6215/39/1/1: Vegetable farming: persuasion of onion farmers in the Caledon Extension Ward to implement improved farming techniques. 1985. C.L. van Rooyen

VITICULTURE/WINGERDBOERDERY

• *Persuasion/Oorreding*

- V.6216/39/1/1: Viticulture: the persuasion of grape farmers in the Upington Extension Ward to apply pre-harvest bunch treatment. 1988. D.J. Malan
- W.6216/39/1/1: Viticulture: persuasion of farmers in the Vredendal Extension Ward to apply correct techniques of winter pruning and manipulation of summer foilage. 1985. S. Lutz
- W.6216/39/1/2: Viticulture: persuasion of farmers in the Vredendal Extension Ward to apply updated techniques of irrigation. 1986. P.B. van der Merwe
- W.6216/39/2/1: Viticulture: persuasion of farmers in the Amalienstein/Van Zylsdamme farming area to implement optimal irrigation techniques. 1985. M.J. de W. Delport
- W.6216/39/3/1: Viticulture: persuasion of farmers in the Mamalienstein/Van Zylsdamme farming area to implement recommended soil-plant combinations, correct soil preparation and establishment techniques for perennial crops. 1985. M.J. de W. Delport
- W.6216/39/3/2: Viticulture: persuasion of farmers in the irrigation areas of Montagu Extension Ward to implement recommended soil-crop combinations, correct soil preparation and establishment techniques for perennial crops. 1985. W.J. Basson
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AGRICULTURAL ENGINEERING SERVICES LANDBOU-INGENIEURSDIENSTE

Agricultural mechanisation/Landboumeganisasie

POWER SOURCES AND LABOUR/KRAGBRONNE EN ARBEID

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- LI.6711/51/1/1: Evaluation of tractor characteristics - power take-off shaft and safety frames. 1982. J.J.P.C. Swanepoel
- LI.6711/51/1/2: Power sources and labour: performance of two-wheel, four-wheel and crawler track-driven tractors under a variety of conditions. 1981. R.W. Otterman

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- *Engineering/Ingenieurskunde*

- LI.6712/51/1/1: Engineering aspects of agricultural machinery. 1982. A.J. Heyns

Agricultural structures and facilities/Landboustrukture en -fasiliteite

CLIMATE-CONTROLLED STRUCTURES/KLIMAATBEHEERDE STRUKTURE

- *Engineering/Ingenieurskunde*

- LI.6722/51/1/1: Engineering aspects of climatic-controlled structures. 1982. P.J. Britz

STOCK HOUSING AND FACILITIES/VEEBEHUISING EN -FASILITEITE

- *Engineering/Ingenieurskunde*

- LI.6723/51/1/1: Engineering aspects of animal housing and facilities. 1982. P.A. Henning
- LI.6723/51/1/2: Engineering aspects of animal housing and related facilities in the Winter Rainfall Region. 1982. J.C. Venter

Irrigation and drainage engineering/Besproeiings- en dreineringsingenieurswese

IRRIGATION/BESPROEIING

- *Engineering/Ingenieurskunde*

- LI.6731/51/1/1: Engineering aspects of irrigation. 1982. F.B. Reinders

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- LI.6732/51/1/1: Engineering aspects of sub-surface drainage systems. 1982. F.J.C. Hugo

BOTANY/BOTANIE

BOTANY RESEARCH/BOTANIESE NAVORSING

Plant taxa/Planttaksons

FLORA

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- PL.7111/01/1/6: Flora of southern Africa: Liliaceae - Dracaenoideae and Asparagoideae. 1979. G.E. Gibbs Russell
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- PL.7111/01/1/23: Flora of southern Africa: Salicaceae, Fabaceae, Urticaceae and Piperaceae. 1984. K.L. Immelman
- PL.7111/01/1/24: Flora of southern Africa: the tribe Tephrosieae (Fabaceae - Papillonoideae). 1985. B.D. Schrire
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- PL.7111/01/1/27: Flora of southern Africa: the tribe Indigofereae (Fabaceae-Papillonoideae). 1987. B.D. Schrire
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- PL.7111/01/3/2: Pretoria National Herbarium Computerised Information System (PRECIS) for the flora of southern Africa: Taxon Database. 1986. G.E. Gibbs Russell
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- PL.7112/01/1/1: Taxonomy of Angiospermae: the family Polygonaceae. 1979. T.H. Arnold

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